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EDITORIAL

C. FRANCIS HARDING

Vice-President of the Society

The Society for the Promotion of Engineering Education is a powerful organ underlying the industrial growth of America. If one adopts the conservative estimate that engineering education has been improved twenty-five per cent in efficiency during the past generation as the result of the activities of this society, who will venture to evaluate the industrial and economic growth of the country dependent thereon? What was your share therein?

But that is a matter of history! What of the future? What will our 1931 class of engineers produce before 1951? It gives us pause to contemplate *their potency* and *our responsibility*. What of research, of invention, in their relation to international communication and transportation; to peace; to war; in 1951? May we not well express the hope with L. A. Hawkins in his admirable article upon "Engineering Development and Research" from the following quotation: "Is a Faraday as impossible to produce by education as a Shakespeare, a J. J. Thompson as a Robert Browning? I do not know. . . . I wish only to express the hope that the growth of research work in the colleges and universities will lead to a more general appreciation of its requirements, a quicker perception of real research ability in students, and a better opportunity to encourage and develop that ability.*"

Just as the slogan of the 1928 convention was "Industrial Cooperation" and that at Montreal was "Industrial Leadership," may we not have next June as the keynote of the convention: "Research and Engineering Education?"

* *General Electric Review*, February, 1929.

SOME REACTIONS ON THE MONTREAL MEETING, S. P. E. E.

The most impressive characteristic of an S. P. E. E. meeting is the tolerance which the members quite universally exhibit toward quite individualistic points of view. At the close of the first day at Montreal I had voted the meeting one of the best in the recent history of the Society. The sessions of the second and third days were nearer the level of the commonplace. In Boston the 1912 meeting had devoted its attention very largely to Management: That seems to have been a little too much for us. But, Elliott D. Smith's discussion of the problems of teaching Management was a distinct advance along this line. His ideas approach nearest to a Psychology which has come down to earth of anything I have ever sampled. His method has in it the solution of no end of problems in engineering education. That Elliott D. Smith's discussion on Thursday evening was a hard one for the membership of the Society to assimilate but, on that very account, interesting and probably epoch-making.

Excellent arrangements, well prepared papers, pertinent discussions, and a spirit of good fellowship, were the outstanding features of the recent S. P. E. E. meeting in Montreal. In addition there was statesman-like preparation to deal with forthcoming major problems as shown by the move to draw closer to the founder engineering societies.

The chief value of any S. P. E. E. meeting is the opportunity it affords for personal contacts and informal comparing of experiences. It was a fine thing to be able to do this with our Canadian cousins at Montreal.

Place and circumstances: Everybody was glad to go to Montreal and appreciated the comfort and courtesy of our entertainment. Program: Plenty of good material well presented. Spare time: Not enough. There should be a definite time in the program to see things of engineering interest in the institutions and in the city. General discussion: The appointed speakers occupied, by arrangement, so large a part of the time in each session that there was little or no opportunity for general discussion. A serious loss.

I am personally more interested in the small sectional meetings, rather than in the general meetings. In my opinion it is a great

waste of time and energy to travel hundreds of miles to listen to some talk which might equally well be printed and read at leisure. Personal contacts on the other hand I find most stimulating and helpful and naturally points are brought out and discussed in a way that it would not be possible in a paper.

Another thing, that I speak of with some diffidence because I may be entirely misinformed, was the apparently cut and dried manner of the elections. It appeared to me that a small group were in complete control of the Society. As I say, I may be entirely wrong as this is merely a hasty reflection and I give it to you for what it is worth. I do not wish to imply that the Society has in any way been mismanaged. It merely struck me that the average member was completely lost and had little or no say regarding the policy of the Society.

The Montreal meeting was a most profitable one from the viewpoint of the papers submitted. The epitomization of faculty relationships gave everyone a mental "fillip" which must provoke much thought and some results.

The meeting was particularly well organized and the hospitality afforded on the part of McGill University thoroughly appreciated. Comments were numerous regarding the courtesy and attention extended to the ladies. One particularly interesting fact developed from the summary of the study of Engineering Education presented by Dean Bishop, was the almost universal rearrangement of curricula to conform with recommended changes in credit hours or work and in the general relation between technical and non-technical subjects. The advance and proposed suggested improvements in the teaching of English to engineers was noteworthy and the conference on this subject most helpful.

I have been a constant reader of the Journal of the S. P. E. E. for the last fifteen years, but the annual meeting of the Society with the personal contact and exchange of ideas at first hand with representatives of other institutions is certainly much more gratifying and instructive.

Too much emphasis placed upon training for the trades instead of engineering as a profession. The banquet was a great success.

In the first place, I would like to tell you that I derive the greatest enjoyment from the S. P. E. E. meetings. I look forward to

these gatherings with the utmost pleasure. Now the Montreal meeting was very enjoyable, but as I believe I have written you in the past, there were probably too many papers and not enough time for social gatherings. Meeting our colleagues is one of the agreeable features of these meetings. But don't think I am criticizing you or the Council, because I realize the importance of the papers presented. If we could concentrate our efforts and discussions on one or possibly two problems which have been studied by the Board and permit more time for social visiting, I would like it better. May be, however, I am in the minority.

I enjoyed the hospitality of McGill University and l'Ecole Polytechnique; and received the usual inspiration from the renewal of friendly contacts with S. P. E. E. members. The papers that were offered were good; but the program was too full to permit the desired discussion.

The Montreal meeting was the best of the sort that I have ever attended. There was the usual good fellowship which characterizes the S. P. E. E., and every part of the program well worth while.

Briefly I feel that more time should be given to group discussions of the round table order.

A good program; splendidly housed and handled.

Feel that the Montreal meeting was very much worth while.

The meeting of the Section on Electrical Engineering at Montreal was the most enthusiastic one we have so far held. The talks by Mr. Smith of Yale and Mr. Lewisohn impressed me particularly. I can't understand why such a large group of men will come all the way to Montreal and then not go to hear these two men. What they had to say affects engineering education vitally, yet the attendance was entirely too small. The compilation by the Secretary of the data on engineering schools, obtained by the Office of Education, I found very valuable.

During the past few years the S. P. E. E. has exhibited a new vitality. The meeting at Montreal reflected this change. The cause we believe can directly be traced to the self investigation of engineering education and to the summer conferences for engineering teachers both of which have contributed to the Society a feeling of substantial accomplishment and future outlook.

I especially enjoyed the meetings on various subjects held on the first day of the Montreal convention. I would like to suggest that some of these conferences on special subjects be scheduled so as to permit one to attend more than one conference. The entire convention was so splendidly arranged and carried out that any other comment is necessarily congratulatory.

For me the Montreal meeting was an outstanding success. The real interest in educational matters, reflected by the papers and committee reports presented, awakened a new confidence in the work of the Society. I am proud of its outstanding accomplishments in the field of educational research.

Outstanding feature was a two-hour visit with Professor E. G. Burr, Department of Electrical Engineering, McGill University. He talked about the Ottawa River power developments and reminisced about Alexander Gray.

While I enjoyed the Montreal meeting, I am afraid that outside of the annual dinner and possibly one or two papers it did not leave many lasting impressions.

I was very much interested in the Montreal meeting, although the material was more general than usual. It seems to me that it must need be so as the summer schools and different groups will take the place to a certain extent of a detailed program. I for one was very well satisfied with the meeting.

From the standpoint of program subjects discussed, speakers, meeting rooms, etc., I feel the Montreal meeting left nothing to be desired. As valuable as the meetings were the pleasant associations and the cordial good fellowship of all in attendance were alone well worth the trip. As hosts the McGill University set a high standard of hospitality. The secret of the success of the whole convention is not hard for me to know.

I was very much impressed with the meeting in every respect the regular session program was very splendid and I do not see how the social functions could have been improved. I consider it a very successful and profitable meeting and hope that I may have the pleasure of attending the one scheduled at Purdue next year.

The Montreal meeting impressed me most favorably. Each institution visited by the convention has its own local environment, traditions and pedagogical methods that contribute greatly to the

values received by regular attendants. The S. P. E. E. is now a most helpful and powerful factor not only in the pedagogical but in the engineering and industrial world.

The meeting in Montreal was interesting and instructive. A great deal of ground was covered in the time available, but a lighter program would be more enjoyable and would make it possible to have more discussion of the papers.

I have attended every meeting of the S. P. E. E. over a period of many years and have always enjoyed and profited by every one of the programs. It seems to me that the Montreal meeting will always stand out as one of the best ever held. There were many good papers presented and addresses delivered. To my mind the two outstanding items on the program were: first, the address of welcome by Sir Arthur Currie, and the second, the presidential address by General Rees. Each of these addresses contained much constructive material. The presentation of the Lamme medal to Dr. Charles F. Scott was most impressive and will long be remembered as one of the bright spots of the Montreal meeting. The recipient was more than worthy of the great honor bestowed upon him.

Meetings of the S. P. E. E. which are held in centers where it is impossible to be grouped in close contact with each other are not as successful as meetings held in smaller communities. It is my opinion that programs of the kind which were presented at the Montreal meeting will fail to hold the interest of engineering teachers in the S. P. E. E. Personally, I feel the need and I have heard others express a similar idea, namely, that there is the need for a Renaissance in the Society so far as its general conventions are concerned.

I was much interested in the group meetings and would like to attend more of them, but wish they were scattered so that I could attend more than one subject. I thought that most of the Council business might have been done by correspondence or committees, making the Council meetings less arduous and more important.

Good in every particular but there was not time enough for the program as set up. General Rees set a pace that others will have difficulty in matching, and he deserves much credit for the success of the meeting. These sessions should not be carried over into Saturday afternoon. It was unfortunate that so many missed the excellent program presented at that time.

I profited much by the Montreal meeting and enjoyed greatly the hospitality of our Canadian friends at McGill and l'Ecole Polytechnique. The efforts of President Rees, Secretary Bishop, and our hosts to provide a worth while and stimulating program were most successful and I am sure were appreciated by all those present.

The Montreal meeting of the S. P. E. E. was an earnest meeting of educators in the discussion of their problems and like its predecessors will prove fruitful by adding to the spirit of coöperation amongst the engineering schools and their faculties, and between the engineering schools and the industries. The choice of the recipient on whom the Lamme Medal was awarded and the fact that suitable representatives are still active amongst us. If the change in the name of the Society, which was recommended by the Council, is put into effect, this also probably will have a desirable influence.

The Montreal meeting was interesting and successful, particularly in the fact that we were able to see and learn of the Canadian methods in education and research quite completely. As usual the program was crowded but I am not certain that it would have been as successful if the opposite effect had been produced, namely, too contracted a program. We should have more discussions in the S. P. E. E. meetings.

I consider the Montreal meeting one of the most interesting meetings that it has ever been my pleasure to attend in the past twenty years. Especially was this so because of the hospitality shown, interesting papers presented and the new acquaintances made of teachers who do not usually attend meetings in other parts of the country. I wish to congratulate you upon the smoothness with which this meeting was run, and particularly upon the program presented at the annual banquet—such programs are of real value.

A less extended programme with a little more time available for discussions might be an improvement.

A very interesting and instructive conference, conducted efficiently and with dispatch. I believe, however, the value of these conferences could be increased if it were possible to schedule the group meetings at different times. Many of us are interested in several phases of the educational program but because of conflict were able to attend but one group.

The new division on the Coöperative Plan of Education held its first session at the Montreal meeting. There were over fifty in

attendance including most of the plant representatives who had come to Montreal. The live interest which developed in discussion indicated that this division is of importance and should be given two half days instead of one. The whole Montreal meeting was a success from the writer's point of view.

Meetings at Montreal could have been held in two days. Would like to see a section on Machine Design and Materials of Engineering again.

The point that impressed me most regarding the meeting and its program was the amount of attention paid to discussions of human relations. Such a program could hardly have been carried out a few years ago because engineers had thought so little of personnel relations but continued to lay stress upon materials and methods. It is a very significant thing I believe that the engineering profession is taking up these problems and it will surely increase the prestige of the profession.

The program in Montreal this year was very interesting and instructive. I was especially interested in Professor Smith's presentation of "Training Engineers to Handle Men."

The Montreal convention I found helpful, instructive, and broadening. The papers were good and on pertinent subjects but opportunity for discussion was too restricted. The idea of one social period (afternoon or evening) each day is to be commended. An excursion might be worked in another time. Sessions after the banquet seem suggestive of an anti-climax.

International character of meeting particularly pleasant. General programs full of inspiration. Would like to see section meetings scattered through a longer period so that one might attend meetings of more than one section even though section meetings might conflict with some of the general meetings. Would even eliminate some of general meetings if necessary.

The Montreal meeting was to me both pleasant and profitable. However, the time of the meetings was too short for anything like a full discussion of the papers. This was particularly true of the sectional meetings. This condition indicates a high degree of interest in the work of the Society.

I found the Montreal sessions very interesting and instructive.

Unusually delightful hosts, an efficient and practical local committee, an interesting and well balanced program, and an effective and dignified presiding officer all combined in making the Montreal meeting a most happy reunion for those interested in engineering education.

Thoroughly enjoyed the Montreal meeting, both the papers and the friendly hospitality of our hosts. It was my first visit to McGill, of whose splendid record I was well aware, which made the sessions particularly interesting. The only suggestion I can offer for another year is that more time be allowed for discussion and papers of a controversial type be solicited. I do not believe enough members take part in the proceedings.

I am sure all will testify to the meaty program and the warm hospitality of McGill University. In addition I want to express appreciation for the atmosphere of open-minded interest in our new problems in teaching. There was a friendly give and take during informal discussion more enjoyable than any I have previously experienced.

The technical sessions of the Montreal convention were very interesting. Taken all in all, the trip to Montreal was worth while to me. I was very much disappointed to find that the A. I. E. E. and S. P. E. E. conventions overlapped so that I had to miss important parts of each. I hope that this may be avoided in the future.

The Montreal meeting was worth a much larger attendance than it received. The numbers that seemed outstanding to the writer were the paper by Professor Smith, and President Rees' presidential address. The latter was a forceful challenge to the engineering profession which will bear repeated reading. Very probably it would have escaped my attention had I not been there.

The unsatisfactory feature of this meeting, as of others, was the tendency to crowd the program. Less papers per session would have allowed greater freedom of discussion. When the chairman is fighting for time, the ablest discussion leaders refrain from taking part.

In the session devoted to group conferences, it usually happens that meetings on related subjects are held simultaneously. At Montreal, for example, one was unable to attend both the sessions on coöperative engineering and industrial engineering, or both the sessions on machine design and mechanics. It was a case of choose one or the other. This could be avoided in the future by giving an entire day to these conferences.

The Montreal meeting seemed doubly enjoyable because of the scenic delights of the water trip down the St. Lawrence valley and the historic interests of the city itself. At the risk of being misunderstood, it is wished that all our meeting could equally combine vacation with business.

The vigor and interest of the sectional conferences with their intimate contacts and stimulating exchange of ideas and practices was one of the most gratifying experiences of the conference.

The opening session in Moyse Hall colored by such personalities as Aurelien Boyer, Sir Arthur Currie and General R. I. Rees, and vitalized particularly by the presidential address upon "Engineering Leadership" I am sure gave a great inspiration to all in attendance and left a sense of the responsibility of the engineering educator that should stimulate the constructive expression of many improvements and accomplishments in education.

I think perhaps one of the most pleasing moments of the conference was the presentation of the Lamme medal to Dr. Charles F. Scott, who was the first recipient of the medal personally to receive it at the annual banquet where the award is announced. Dr. Scott's personality and manner, together with his most unusually accomplishments and contributions, gave one a great sense of satisfaction and agreement with the committee's choice.

I have no criticisms to make of the meeting. I enjoyed all the meetings that I attended and I was especially pleased with the cordial entertainment accorded us by McGill University and by l'Ecole Polytechnique.

It seems to me that the S. P. E. E. has acquired sufficient importance to manage its own affairs. So far as the importance in engineering education is concerned, I believe that this organization should take the lead. By that I do not mean that it should undertake projects that would be antagonistic to other educational organizations, but I do believe that in such matters as the sponsoring of summer schools for the benefit of teachers in engineering schools, its officers should feel that they are vested with full authority. In the section devoted to mathematics, it seems to me that there was a tendency to over emphasize very advanced mathematics as compared with mathematics that is taught to engineering students, even in our best technical schools. Surely we want to keep alive the spirit of research for without that the teacher becomes a mere automaton. On the other hand it would be profitable, I think, for some specific attention to be paid to the importance of teaching mathematics in our schools of technology—not only by a better

presentation of the subject, but by investigation on the part of the teachers relating specifically to the adaptation of the content of their courses to the practical use that will be made of the subject by engineers. This applies to the work in elementary mathematics during the first year, to the courses in Calculus which follow and, most of all, in my opinion, to the particular courses in Differential Equations that will be used in a practical way by engineers.

The address of President Rees was thoughtful and helpful. Coming from a representative of "big business" it was encouraging at the same time that it emphasized the importance of the essential factors in the training of young men for engineering and industry. The several addresses on the teacher and his possible influence on his students, his fellow teachers, and on society were all forceful and timely. The social arrangements made by the Montreal institutes were admirable and added much to the comfort and enjoyment of a very successful convention.

My reactions on the Montreal meeting were similar to those experiences at the National Societies—I find it impossible to be in two places at the same time. Otherwise, I think that on the whole they were successful.

Shorter programs and more time for discussion.

Aeronautic education is sensibly engineering and should be so interpreted. That aeronautics is here to stay is admitted, and is expected to occupy a prominent place, certainly a front seat for many a year, until some greater discovery of humanitarian benefit displaces it.

My reaction to the Montreal meeting is in the nature of a suggestion. There was held in St. Louis last spring and at the city holding the National Air Show each year in the future a meeting on Aeronautic Education. This meeting was sponsored by the Aeronautic Chamber of Commerce, through its educational committee. Could the S. P. E. E. not rightfully assume this to be one of their activities as a Sectional Meeting on Aeronautics and coöperating with the Aeronautic Chamber of Commerce and such other agencies as may have interest therein, to make these Aeronautics meetings mean something far above what they do to-day and to guide and assist those offering courses in Aeronautics? As a member of the Education Committee of the Chamber the writer would be happy to place such matter before the Chamber provided the S. P. E. E. can see its way clear to assume this magnificent opportunity.

The convention was delightfully entertained by McGill University and l'Ecole Polytechnique. Although somewhat crowded, the program, clustered about an important theme, was substantial and stimulating. It may be remarked also that the last session was one of the best.

In my opinion the Montreal meeting was very successful. The programs were interesting, the entertainment and other details were well taken care of by the local committee. See you at Purdue next June.

The following appear to me to be the outstanding reactions of the Montreal meeting as interpreted from the papers and discussions presented:

1. The increasing realization of the vital importance of the personality and individuality of the teacher as a valuable function in Engineering Education.
2. The further emphasis of the value of downright fundamentals, with curricula stripped of many of the "side line" subjects which have been prevalent in recent years.
3. The inspiration which can be derived by students from teachers who are *real* men of high ideals and who are *real* engineers closely in touch with the affairs of the country.

The Coöperative College session was unquestionably the best yet and augers well for the affiliation with the S. P. E. E.

Very enjoyable meeting from all viewpoints. Excellent program. Delightful hospitality. Interesting Canadian atmosphere.

The single suggestion that I have is that the devisional sessions be **not** held simultaneously. At least ten members came to me and stated they wanted to attend the Machine Design meeting but for one good reason or another they had to attend other sessions. Likewise, some who attended the Machine Design session would also have liked to attend other sessions.

T-SQUARE PAGE

Division of Engineering Drawing
Organization and Work

Executive Committee

Thos. E. French, Chairman, Ohio State Univ., Columbus, Ohio; term expires, 1931.
R. P. Hoelscher, Sec'y., Univ. of Illinois, Urbana, Ill.; term expires, 1931.
William G. Smith, Northwestern Univ., Evanston, Ill.; term expires, 1931.
W. E. Farnham, Tufts College, Tufts College, Mass.; term expires, 1935.
F. G. Higbee, Univ. of Iowa, Iowa City, Iowa; term expires, 1933.
H. H. Jordan, Univ. of Illinois, Urbana, Ill.; term expires, 1931.

Committee on Engineering Drawing

A study of and a report on the material presented at the 1930 summer session relating to the teaching and content of engineering drawing courses.
H. M. McCully, Chairman, Carnegie Inst. of Tech., Pittsburgh, Pa.
C. L. Svensen, Texas Technological College, Lubbock, Texas.
John M. Russ, Ohio State Univ., Columbus, Ohio.
F. DeR. Furman, Stevens Inst. of Tech., Hoboken, N. J.
G. C. Anthony, St. Louis, Missouri.

Committee on Descriptive Geometry

A study of and a report on the material presented at the 1930 summer session relating to the teaching and content of descriptive geometry courses.
W. G. Smith, Chairman, Northwestern Univ., Evanston, Ill.
F. M. Porter, Univ. of Illinois, Urbana, Ill.
A. V. Millar, Univ. of Wisconsin, Madison, Wis.
Geo. J. Hood, Univ. of Kansas, Lawrence, Kans.
One Member to be selected to replace Chas. W. Thomas, deceased.

Committee on Research

A study of and a report on problems for research in fields of engineering drawing and related subjects including the teaching of these subjects.
C. V. Mann, Chairman, Univ. of Missouri, Rolla, Missouri.
H. H. Jordan, Univ. of Illinois, Urbana, Illinois.
Chas. H. Schumann, Jr., Columbia Univ., New York City.
H. W. Miller, Univ. of Michigan, Ann Arbor, Mich.
H. B. Langille, Univ. of California, Berkeley, Cal.

Committee on Summer Sessions

To act as advisory editors in publishing the material presented at the 1930 summer session on engineering drawing.
F. G. Higbee, Chairman, State Univ. of Iowa, Iowa City, Iowa.
W. E. Farnham, Tufts College, Tufts College, Mass.
F. M. Warner, Univ. of Washington, Seattle, Wash.

Committee on Drafting Instruments

To compile a report on drafting instruments together with specifications for their manufacture.

F. M. Jones,
J. L. Hodge,
W. F. Stone,
G. H. Frey,
T. M. Brown.

In June, 1929, the Society for the Promotion of Engineering Education appointed a Committee on Instruction in Industrial Relations. After careful investigation, the committee came to the conclusion that the subject was of such importance that a thorough study of the possibilities, aims and methods of teaching engineering students to manage men should be made during the year and the results of this study submitted to the 1930 meeting of the Society at Montreal in June.

To carry out this purpose the committee elected to its membership Professor Elliott Dunlap Smith and requested him to head this study and to put the conclusions reached in form for presentation. A condensed statement of the results of this study has been prepared to present the fundamentals of the problem for deans of engineering schools and others broadly interested. This has been supplemented by a fuller statement of methods for the use of teachers.

These statements are herewith presented to the Society as the special report of its Committee on Instruction in Industrial Relations.

R. L. Sackett, *Chairman,*
F. E. Ayer,
J. W. Hallock,
D. S. Kimball,
S. A. Lewisohn,
Joseph Roe,
E. D. Smith,
J. E. Walters,
F. W. Willard.
R. I. Rees, *ex officio.*

May 10, 1930.

CAN THE ENGINEERING STUDENT BE TAUGHT TO MANAGE MEN?

Special Report of the Committee on Instruction in Industrial Relations.
Prepared by Elliott Dunlap Smith, Yale University.

Success as an engineer is more and more calling for executive as well as technical ability. Over three-fourths of all engineers, the Wickenden report shows, go into administrative work and must manage men. Even engineers who concentrate on design or research must be able to deal effectively with superiors, associates, and usually subordinates. Because of this there is a growing demand that engineering schools provide some direct preparation for this important aspect of engineering work.

What then is it essential to provide? And what is it possible to provide in the limited time which can be taken from other engineering education? As few engineers ever become personnel or employment managers, it is hardly warranted to ask them to turn aside from the study of their own profession to acquire proficiency in the technique of another. Moreover, ability to deal with or manage men is an intangible and subtle attribute. This raises the question of whether it can be taught at all. Are not managers born and not made? And in so far as skill in the management of men can be acquired, must it not be acquired from experience rather than from instruction?

Aptitude for acquiring skill in human management, as in other fields, unquestionably depends largely on deep-seated traits. These traits, however, are of relatively little value unless they are developed. It is as unsound to expect executive aptitude to ripen into mature executive ability without training as it is to expect scientific aptitude and ingenuity to develop untaught into engineering skill. While no instruction can replace actual experience in learning to deal effectively with human nature, experience, here as elsewhere, favors the mind which is prepared.

There are two characteristics of experience that make it

important for the student to be fully prepared before matriculating in its school. In the first place, experience is haphazard, not systematic, in its lessons. Even where a company definitely undertakes to provide the young engineers in its employ with developing experience, actual personnel experience cannot be systematically controlled. A company cannot have a strike, or even have a worker lose his temper, for example, at the time most desirable for educational purposes. Much that is educationally vital in experience with human nature is prohibitively expensive. Unless a young engineer has a systematic understanding of this subject and can read an orderly arrangement into the lessons of personnel experience, the assimilation into usable form of the confused medley of experiences which he encounters is a baffling problem. In their infinite variety and apparent inconsistencies, the interrelation of the lessons of experience is lost sight of and, as with all hit or miss methods, progress is costly and slow.

In the second place, experience with human relations rarely makes clear the errors for which it has exacted punishment. Unless a young engineer has been taught in school the fundamental characteristics of human nature and the fundamental problems of human contacts and industrial relations, he is likely to miss the lessons of such experience altogether. Industrial situations are so complicated and human contacts so subtle that it is difficult to discover just what it was in any situation which turned the scale on the side of success or of failure. Often when serious consequences have followed from some failure in management of men, even seasoned executives have overlooked this failure and sought the cause exclusively in equipment or in process, or have seen it in the assumed fault of the employees or of "the other fellow." The very complexity and subtlety of problems of human relations makes it especially important for the student to be prepared adequately to learn the lessons of experience in regard to them.

The danger of overlooking the human aspects of the lessons of experience is especially great with young engineers.

They have been trained to be precise in the mathematical sense. In school they have had their attention directed primarily upon the material aspects of industry. In their early years at work, their tasks are usually confined to problems of materials, mechanisms and process, the human aspects of which are not emphasized nor clearly apparent. Unless they have been made aware of the personnel aspects of their work by adequate training while in school, young engineers are likely to continue for years without deriving from their experience increased capacity to deal with or to manage men. Then, when they later attain positions of executive responsibility, or when the carrying forward of their research or developments calls for the enlisting effective support or cooperation, they find themselves ill equipped. It is because of this situation that outstanding business executives are uniting in urging engineering schools to take measures better to prepare all technical students to handle personnel problems.

What then can engineering schools do to provide this important preparation? Fortunately, out of the mass of accumulated experience in human contacts and industrial relations, underlying principles and tested practices are gradually being evolved. Especially through the application of psychology to its problems, the management of human relations in industry is rapidly becoming an applied empirical science. Hence, although in the field of human contacts more than any other, it is impossible to reduce management to the mere manipulation of precise measures, the engineer who has a sound understanding of the experience of the past—of the situations which have arisen, of the measures which have been taken, of the results which have followed and of the principles underlying them—will have a large advantage over those engineers whose background is confined to their own necessarily narrow and haphazard experience. Thus, although a mastery of the techniques of the industrial engineer or the personnel manager is properly confined to courses for students designing to specialize in these fields, a sound understanding of the underlying experience and principles of

human relationships in industry is of value to all engineers. Such a background can be adequately provided only through a course dealing directly with this subject.

The evasiveness of the human factors in the lessons of experience, and the tendency of engineering training and work to divert attention from them, makes it outstandingly important that this background be not merely an academic one. In human relations men wisely distrust the "mere theorist." With so subtle things as human contacts and industrial relations: theories, information, or practices which are not assimilated by application to actual situations are unlikely to be of substantial value and may even be dangers.

In considering the addition of courses on human relations in industry to the curriculum of engineering schools, these fundamental purposes should never be lost sight of. In engineering schools we are not making personnel managers and we cannot make finished executives. Our aim is to equip engineering students to learn from experience how to deal with and how to manage men. While it is important that they gain an understanding of present-day industrial relations practices and experience, it is far more important that they develop effective attitudes and methods.

With such an objective it is obvious that a satisfactory course cannot be transplanted ready-made from the field of professional personnel management, nor can the standard methods of technical training be employed without adaptation. What is essential in subject matter is that the students be systematically exposed to situations and problems which comprehend the principal sorts of personnel experience an engineer or executive will encounter in his work, and that they be given sufficient background to be able to comprehend these problems as part of an orderly understanding of human relations in industry. What is essential in method is that the student be brought to think independently but systematically and incisively about these problems, and to recognize in them their subtle human elements.

To fulfill these conditions the best type of course will con

sist primarily neither of lectures nor recitations, but of discussion and actual handling of typical personnel situations. These situations should involve genuine problems which the students will recognize as real, and enter into seriously. They should be related as far as possible to the student's engineering work so that he will be brought to see the personnel aspects of the work in which he is actually engaged at the time. These situations should be carefully arranged so as to involve in orderly sequence the main types of personnel problems which the student is likely to encounter as an engineer and as an executive, for it is just such an arrangement that actual experience fails to provide. Whenever the limitations of class instruction permit, the student should be required to deal with these situations by action, not merely by discussion. In all cases the instructor should insist that the situations be analyzed and conclusions arrived at by an orderly method of approach. The background of fundamental principles, tested practices, and industrial experience are best provided incidentally to the study and discussion of the situations, thus being learned in relation to the handling of actual problems as material which has grown out of actual experience and is capable of practical use.

We attach to this report suggestions as to the teaching of such a course. The teaching of the management of human contacts and relations by this method involves more mature and qualified leadership than is required for the typical text-lecture-recitation course. It is not possible for the instructor to lean heavily on the text, for when discussion is free he must know the field thoroughly from every direction in which discussion may turn. On this account, we have also given suggestions for a lecture and recitation course. We wish to emphasize, however, that what is essential is the development of habits in the student which will render him sensitive to the human aspects of the situations with which he will later come in contact and will cause him to approach these situations systematically and effectively. This can only be accomplished through a subject matter related to his own present and fu-

ture problems, through a background of principles that the student recognizes as growing out of actual experience, through methods that cause him to think and act—not merely to remember and repeat. Whatever form of instruction is employed, these fundamental purposes should be kept in mind.*

In whatever branch of engineering a student persues, the development of ability to deal with men will be of primary value. Such a course as we have described is thus part of a general engineering education.

SUGGESTIONS FOR TEACHERS OF COURSES IN MANAGING AND DEALING WITH MEN

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No methods can solve the problem of teaching engineers to manage men. Such teaching even more than the teaching of technical subjects, is an art that can never be reduced to rules. Good reading material, good problems, good examination questions, good arrangement and good principles of conducting classes, all are important. But after all, these are but

* *Note:* The importance of these fundamental purposes, even in teaching material science, was vigorously pointed out by Frederick W. Taylor in a letter to M. H. LeChatelier. "It seems to me of vastly more importance to teach the student, first, the broad general principles underlying a science; second, to show him the true scientific methods of investigation (such as were adopted by Moissan), and, third, to lead him to use his own brains and initiative in approaching any new subject, rather than to attempt to cram students with a mass of detailed information."

instruments of teaching, of little value in themselves. The success of such a course comes far more from the character, interest, experience, and intellectual power of the teacher and from his capacity to see behind the subject matter and the methods of his course, the purposes for which it is intended.

It is with full realization of the limitations of teaching methods, of the importance of varying and adapting them to local conditions, and of the predominant importance of the teacher, that the following suggestions as to courses on personnel problems of engineers and executives are given.

I. SUGGESTIONS FOR A DISCUSSION COURSE

The outstanding characteristic of a discussion course in personnel problems is that it may provide a condensed, systematic exposure of the student to the principal types of situation that an executive or engineer will encounter in dealing with human beings in his work. Unless the course is so conducted as to cause the student to think vigorously, systematically, and above all, independently about these situations, it is a slow and wasteful method of teaching. If this is done, however, this method is more than justified in the power of discernment and effective disciplined thinking it develops. Throughout, the course should be devised and conducted with this in mind.

A. Conducting Classes

1. *Developing Discussion.*

The essentials of developing discussion are the provision of worthwhile genuine problems, an orderly progressive development of the problems, and fair play in handling the students.

The problems must be genuine.—Students enter earnestly into the discussion of problems in which they are interested. To be really interested in the discussion of a problem they must believe that the problem is a worthwhile problem with which they are qualified to deal. If the problem is trivial or academic, students are unlikely to be interested in discussing

it. If there is an exact answer stated in the reading, the question is a "quiz" and not a discussible problem at all. If, after the class has made an honest effort to develop a sound decision by discussion, the instructor pulls a predetermined categorical answer out of the hat of his special information, the students feel defrauded and thereafter discussion is likely to be half-hearted. Usually the test of whether the discussion has been genuine and of value to the students is whether the instructor has himself in some degree modified or clarified his own opinion as a result of it.

The discussion must get somewhere.—Even vigorous discussion is of little value if it does not stick to the point and get somewhere. Unless it is confined to an orderly development of the problem, it tends to become discursive and ineffective. This makes progress slow, and bores all but a few loquacious students. Far worse, it confuses the discussion and develops habits of ineffective and disorderly thought.

It is not necessary or desirable that the discussion follow, topic by topic, some outline worked out by the instructor. Such a method can easily be carried to the point where the "discussions" would be little more than recitations under a new name. The students must be left free to explore the subject in their own way. Nor is it possible to tell in advance just what that way will be, or what combination of circumstances will give some formerly minor point unexpected importance. Nevertheless, if the instructor has the essentials of the problem well in mind, it is possible by asking questions at critical times, by picking out what is essential in some student's statement, by suggesting that diverting digressions be discussed after class, and especially by insisting that one point be cleared up before another is gone into, not only to keep the discussion within bounds but to make it an orderly progressive development of the problem.

Such orderliness of development is helped, especially at the start, by establishing a somewhat standardized sequence of approach. For example, the discussion of each problem may well begin with an analysis of the problem into its major

elements, and a careful elimination of any ambiguities. With classes using a psychological arrangement of material, the further development of the discussion may well follow in succession the principal steps in this arrangement. If such a standardized method of approach is observed with unimaginative rigidity, it will be a cramping and sterile influence. If it is flexibly and imaginatively employed, it may bring freedom as well as orderliness and thoroughness to the discussion. With the main course of the discussion thus charted, greater latitude in the exploration of the subject is possible without confusion. With the main course thus determined, regardless of what topics are brought up or what emphasis is given to particular points by special circumstances, the development of an orderly method of approach is assured.

Frank statements must not be taken advantage of.—In developing orderly discussion, care must always be taken not to discourage honest and frank statement of opinion. Unless a student is unquestionably talking merely to hear himself talk, he should be made to feel that his sincerity and the merit of what he has in mind are recognized, even though the point he brought up cannot for lack of time be gone into.

In answering discussion from the floor, it is always important to take a student at what he meant or would like to have said, rather than at what he actually said. Students, because of inexperience, frequently say things in a way that if taken literally is quite different from what they intended. While it is often desirable to insist on precise statement, this must be done directly. If the instructor differs with what was literally said when it was not what was meant, and publicly proves that what was said was wrong, the student feels that he has been unfairly treated. Thereafter he hesitates to attempt to express his point of view for fear of being taken advantage of again. I have seen this happen with a college teacher of considerable excellence. By that mistake alone, he ruined an interesting course.

If, on the other hand, the teacher catches and helps the stu-

dent to state the idea that he was earnestly feeling his way toward but was not able clearly to express or even entirely clearly to envision, the student gains a sense of renewed self-confidence in trying to express his ideas again. When the underlying idea has been recognized in this way the instructor can bring it up for further discussion by other students, or vigorously differ with it himself without in any way imperiling future responsiveness.

The instructor must be prepared.—It is no easy task to handle the free discussion of a lively group of students. The better the class and the more effective the course, the more lively and penetrating will be the excursions into aspects of the situation that for one reason or another have "struck home" to the students. Under the fire of statements, comments and questions, the instructor cannot follow the order of his notes. Often he hasn't even an opportunity to refer to them. Again and again, unexpected turns will bring up points his notes do not cover. Unless he has chosen problems that he understands "from the ground up" and has gotten them thoroughly in mind, he is likely to find himself in difficulties and the value of the discussion impaired.

Discussion groups.—In addition to class discussion, the formation of informal discussion groups of from three to six members in the latter part of the course may prove of value. In these groups the students go further into troublesome points brought up in class, and also discuss other problems, often their own. The fact that no instructor is present, while it makes discursiveness almost inevitable, brings about a freedom of discussion and a formation of independent judgment not possible in class.

As an inducement to the formation of such groups, students may be excused from certain reading if they attend a discussion group that meets regularly for a minimum number of hours, and one of their number undertakes to report attendance and the topics covered by the discussions. Usually there is little difficulty in getting students to join discussion groups.

Apart from the direct benefit to the student, such discussion groups often support classroom discussion. Questions debated in the groups are brought up at class, and points of view arrived at in the groups vigorously maintained. Also, the group discussions make clear to the student what in the class discussions he has failed fully to grasp.

2. *Giving Vitality to Class Situations and Problems.*

The importance of making the problem real.—The value of discussing a situation or a problem in class depends largely upon whether it is made real to the student. In the first place, this depends upon whether it is real to the instructor. If, and only if, he enters into it with the energy and enthusiasm of an actual problem that must be dealt with, will it be real to his class. If, and only if, it is real to him can he bring out during the discussion subtle influences and aspects that could hardly be reduced to written statement. For, to a large extent, the written statement of a problem is only an outline which he must fill in from his own background.

In the second place, how real a problem is to the students depends upon how well it is related to what the students have experienced themselves. Many students have actually worked on jobs during their summer vacations. This gives a helpful ground on which to build. Even when they have not worked, their own lives—their homes, their fraternities and their curriculum and extra curriculum work, have furnished valid experience with the major problems of human relations. If this actual experience of the students is built upon by relating the elements of industrial problems to it, a structure of feeling and understanding can gradually be erected that in the end will give a basis for sensing the realities of even such complex situations as group industrial relations.

Bringing discussion down to terms of direct speech and action.—Many problems can be made more real by causing the student to deal by action with certain elements. For example, in handling the problem of getting started in the practice of his profession, each student may be asked to write

a letter of application for the job he would most like to secure after graduation. This brings the problem right home to him. Almost at the start of the course, he not only finds that the course relates to his own life and career, but he is forced to get down from maxims, book statements and discussion to the doing of a job. Then if the next day the instructor sits at his desk and treats the letters as his morning's mail—opens them, reads them out loud and thinks out loud about them—the student is exposed to the experience of hearing his letter through the receiver's ears. "Nothing in this that arouses interest." "When a man has such a good opinion of himself, it must be hard not to have facts to back it up." "Here's a man who has done something and yet he doesn't blow about it!" When this is effectively done it has vigorous reality, sometimes so much so that months later the instructor finds himself burdened with requests to read over proposed letters to prespective employers.

Throughout the course there will be similar opportunities in the discussion of problems, where instead of asking what should be done, the instructor can assume the part of "the other fellow" whether he be superior, subordinate, colleague, salesman or buyer, and require the student to demonstrate his solution in direct discourse. Thus, the problem of what a young engineer, who is learning to operate a machine as his first job in the factory, should do if the workman to whom he has been assigned as assistant shows him how to falsify his production record, has an entirely different "bite" if the instructor translates it into direct discourse and says to the student who has given a descriptive answer: "Well, let's get right down into actual conditions. Assume that I am the workman whose assistant you have been made, and after tipping you off as to how to falsify your production-counter, I say 'See here, Jack—now you're wise, remember you and I are in the same boat and your production figures have got to be right—get me!' Now just what would you do or say at that point?"

Such a dive into direct discourse forces the student out of

the relatively easy area of theory into the harder area of action. It is in this improvisation of impact with intractable reality, however it is brought about, that much of the value of a course of this sort lies. It prevents it from being the mere absorption of information as to practices and theories, and causes it to bring about in the student a capacity to deal effectively with actual conditions.

Bringing the student into contact with experience.—Certain problems, instead of being discussed at all, can be directly dealt with throughout. For example, in studying the problem of handling subordinates, it is not difficult to find cases which can be actually brought into the classroom. The problem of discharging a worker who, in spite of good attendance, good attitude and consistent effort, has failed to measure up to production standards, is of this sort. For the purpose of handling the problem, different students may be assigned to executive positions such as foreman, superintendent and employment manager. If the circumstances surrounding the particular situation require it, a student may also be designated employee representative. It gives greater reality to hire some person from outside of the class to take the part of the employee. Usually some person who has had sufficient industrial experience to enact the part vigorously, and who is willing to do so, can be found. It is essential that the class keep absolutely silent during such a problem, but if it is seriously gone into and the importance of silence made clear, the students soon get so interested that there is little difficulty in this regard.

The facts should be written out and agreed to in advance. The student-executives, subject to the approval of the instructor, should prepare what they consider proper personnel records. With some problems, the actual incident which gave rise to the need for disciplinary action may be enacted in the classroom. From the time the principal facts are set down or enacted, the entire proceeding is spontaneous without pre-arrangement or "coaching from the side lines." Each person handles his own job as occasion requires, and the

entire situation is carried out in the classroom—the foreman's conferences with the employment manager, the notification of the employee who is seated in the midst of the classroom which is assumed to be the work room, the first conference with the foreman, the later conference with the employment manager. Whatever course the case takes it is followed through by actual handling.

It adds to the interest if competing teams are organized, each team handling a different problem in a restricted time and the class voting on the basis of predetermined standards, as to which team did best. Further interest and reality is produced if one or two executives in the community are asked to sit in to observe and to criticize the handling of the situation by the students.

Problems of the buying and selling relationship such as arise in getting a design or program adopted, securing an assistant, determining whether the request of a subordinate is sound, hiring a man or securing a job, are also well adapted to classroom handling. Any one of these situations typifies the factors involved in the others. The problem of hiring a man or of securing a job furnishes an exceptionally vivid illustration of the principles of the buyer-seller relationship, and can be reproduced in class with exceptional reality. The students selected to do the interviewing may be furnished with requisitions ranging from common labor to engineers. Young men and women who have had varied amounts of education and industrial experience, can be hired to come before the class to be interviewed. If they are paid twice as much if they succeed in "getting hired" as if they fail, they will fairly accurately reproduce the behavior of a person "out of a job." If they do not know what job requisitions the students have been given to fill, and if neither the instructor nor the students know anything about the people being interviewed, most of the essential conditions of actual interviewing will be present.

Such interviewing is usually too difficult for an individual student to carry through alone. By making teams of three,

each member of which in turn is to carry on the interview from where his predecessor left off, when one man comes to "the end of his rope," the next, who has had the advantage of watching the interview thus far, is usually able to go forward effectively. After the students have done their best it is helpful for the instructor to complete the interview, bringing out points which the students have missed.

After any problem has been handled in the classroom, the values of this experience may be driven home by discussing at the next class what was and what was not well done. Such cases call for especially full understanding on the part of the instructor. If he has never handled a similar situation in actual life, it is important to enlist the assistance of practical executives in conducting such a problem. Without this assistance, the fact that the instructor has merely a book knowledge of human contacts may become painfully apparent when he is thus brought into contact with reality.

Problems of various sorts may similarly be dramatized so as to be dealt with instead of discussed. Of course, where the students can be brought directly into a work shop and assigned duties, there are exceptional opportunities for supervised actual experience. Still, even when this is possible, there are certain types of experience that can be provided more effectively by class dramatization than work shop conditions would permit. Such direct experience is preferably introduced fairly well on in the course when the students are sufficiently advanced to understand the complex interplay of the subtle factors involved in actual human contacts. Such dramatization can only be applied to certain types of cases, and is too time-consuming to be frequently resorted to. Still, a few such contacts with reality can permeate an entire course with their influence, not merely greatly increasing interest, but by demonstrating the distinction between management theory and the actual management of men, remove from the discussion of problems the glibness with which inexperienced students tend to "round off" difficult situations with easy generalities.

B. Exercises and Examinations

In teaching a course that differs from the standard engineering courses in subject matter and method, exercises and examinations are exceptionally important. They prescribe what the students must accomplish in order to receive credit for the course, and indicate to them what the faculty think is most important for them to get out of it. Consequently, the type of exercises and tests given largely determine the type of studying which the student does.

Exercises

Throughout the course the preparation of problems for class discussion should be emphasized as the primary work of the course. Occasionally, especially at the start, it is desirable to require the students to write out and hand in for criticism their analysis of a problem assigned for class discussion. This not merely insures that the students have made adequate preparation, but gives the instructor an exceptional opportunity to guide the students in developing an effective method of approach to the problems.

Later in the course when the students have a fairly well-rounded understanding of the field, it is of value to have them work out a careful analysis of some problem taken from their own experience. If the student has never worked in an industrial concern, his personal contacts at home or college are almost sure to provide suitable personnel situations. If a thoroughgoing psychological understanding and method of approach have been developed, they will give such a study of an actual problem in the student's life especial value. Such an analysis is so instrumental in making the course an effective part of the student's equipment for life, that it may well be made a major feature of the course.* Repeatedly,

* *Note:* This may be done, for example, by giving as much credit for it as for the mid-term examination. By limiting the paper to a few pages and yet giving so much credit to it, its importance is emphasized and the student induced to prepare it with exceptional care. Mature consideration may be promoted by requiring a statement of the facts of the problem to be prepared several weeks before the final analysis is due.

after such a careful study of a problem of their own, students have taken a new interest in the course through discovering in it a means of better understanding themselves and of better handling their present as well as their future problems.

Tests and Examinations

If it is found necessary to provide frequent tests to insure that the students do the assigned reading regularly and understand it, it is preferable for these tests to ask questions that call for thought, not mere retention. While of necessity they must be short, it is important that they do not throw undue emphasis upon the mere temporary retention of information.

Since students usually discover in advance the type of examinations given in any course, examinations as well as tests and exercises determine what the student will emphasize throughout the year. Because of their length and their position at the end of the main divisions of the course, they give a better opportunity to examine the ability which the student has developed than other means. If the ability to repeat information, rather than the ability to deal with actual situations, is asked for in the examinations, this is likely to relate back and cast its shadow over the entire course, diverting the students' attention from the acquisition of understanding and ability through class discussion, to the mere amassing of information. Since from preparatory school days, in courses such as history and government where there are no precise manipulations to master, the average student has been habituated to amassing and repeating information, it is no small task to cause him to abandon his attitude of seeking to get and to be able to repeat "the dope." Consequently, it is of first importance that the examinations contain few factual questions and consist primarily of original problems of such a nature that no solution in exact categorical terms is possible.

Only such problems can measure the student's ability to recognize and deal effectively with the human aspects of in-

dustrial situations which it is the main purpose of the course to develop. Only such problems can insure the direction of his efforts to the acquisition of this ability.

C. Problems and Situations

Selection and Arrangement of Problems for Discussion

The course should comprehend problems that typify the main types of situations with which an engineer or executive has to deal. Each problem should be chosen because it illustrates the operation of some fundamental principle, or illustrates some important type of human contact or industrial relations situation. What the exact "scenery" of the particular problem may be is relatively unimportant: what is important is whether in understanding it and reaching a sound conclusion in regard to it, the student has progressed in his understanding of human nature and of the factors involved in human relations in industry. To insure this the problems discussed in class must be arranged in an orderly sequence which will make the study of each succeeding problem bring about a systematic development of the student's understanding of the field.

Since a single fundamental principle or type of experience may be illustrated by a variety of situations, a wide choice of subject matter is possible without impairing the particular order of development of the subject that has been determined upon. Hence it is possible to arrange the types of situations in about the order in which the student will encounter them as he progresses in his profession, and at the same time cause the principles illustrated to follow some more fundamental plan. For example, an arrangement of problems starting with the problem of getting a job (and the converse problems of selecting and hiring men), taking next the problems of fitting into a new environment and learning from experience (with the converse problems of training and developing assistants and employees); and after various intermediary steps culminating in problems of employee representation and of unions, follows roughly the course of the

student's future progress and yet proceeds systematically from a study of what is unchangeable and changeable in men, through habit formation and understanding, and other major fields of individual psychology, to problems of group psychology and the integration of group conflict.*

Since a science of human nature is being developed by psychologists and psychiatrists, and since it is already both being effectively applied by experts to particular industrial situations, and being utilized by executives as principles for the guidance of their work, it is desirable that engineering students be equipped to understand and work with it. Already a sound grounding in the fundamental psychological principles which underlie human relations has become of great value to the executive. Through a grasp of these principles he gains a more profound understanding of human nature and a surer touch in dealing with it than is possible by rule of thumb methods alone. Valuable as such scientific understanding is to executives today, it will be much more valuable when the students now in engineering schools reach mature executive positions, for psychology and psychiatry are making rapid progress. It is fundamental, however, that psychological principles be learned in actual application to problems, and the psychological understanding so gained utilized in handling problems throughout the course. To attempt to give a "psychological background" in a few lectures is likely to make psychology for the student a thing both superficial and apart from actual life. To teach psychology in application to problems is to make it a growing basis of understanding which the student knows how to put to practical use. On this account there are important advantages in arranging the problems in a systematic psychological sequence.

If students have not had previous courses in personnel problems, especially if they have not previously taken courses conducted by the discussion of problems, it may be helpful

* *Note:* Suggested arrangements for a course in Personnel Problems for Engineers and Executives on both a psychological and an industrial basis is given on pages 24 to 31.

to preface the course with some broad introductory problem which will both accustom them to the discussion method of study, and will bring them to realize the extent to which personnel problems are involved in what they have looked upon as exclusively engineering situations.

The Qualities of a Good Problem

To deal with a problem superficially is misleading. Even worse, it develops habits of superficial judgment. On this account, it is important to select problems with which the students are thoroughly qualified to deal.

At the start of the course or of a major sub-division, problems must be sufficiently simple to display clearly the fundamental factors at work. At this time it may even be desirable, in order to prevent the operation of fundamental principles from being confused by the discussion of the local incidents of a particular situation, to abandon the discussion of particular situations and to state the problem baldly in general terms. "Under what conditions is exceptionally low turnover desirable and undesirable: among employees? among executives?"

As the student progresses, his capacity to comprehend and to deal with more complicated and difficult material increases. It is thus essential that as the course progresses the fundamental factors of the problems be increasingly overlaid with "scenery" so as to exercise the student's powers of recognition and discrimination. It is equally essential that the later problems involve the recurrence in subtle variation and complex interrelation of the principles developed in the earlier problems. Still, throughout it is important to make sure that the problem is not too complex for effective handling by the student with the knowledge and ability at his command.*

* *Note:* In law schools where the case method was developed, the cases studied are legal "precedents." Besides, the issues in law cases are carefully defined in advance, and the decisions confined to the specified issues. If the discussion method which has worked so well in law schools is to be successfully employed in teaching students to manage men, it

It is not possible, however, to be dogmatic about problem material. What works well with one instructor or group of students may not with another. The above recommendations are of value primarily in suggesting the stresses to which problem material will be subjected when put to use. Each instructor must work out for himself, largely by experimentation, what sort of material is most valuable for him and for his particular classes.

II. SUGGESTIONS FOR A LECTURE-RECITATION COURSE

A lecture-recitation course, like the suggested problem course, should seek to cover the typical personnel situations which an executive or engineer will encounter in his work. In treatment, the course should emphasize the position of the engineer or operating executive. Since little has been written directly from this standpoint, an important function of the lectures will be to interpret from this angle the material provided by the reading.

In general, a lecture course would follow by the lecture method the same sequence of subjects and the same reading in regard to them as a discussion course. The arrangements of subjects and reading given on pages 31 to 35 are as applicable to a lecture course as one taught by the problem method. There is the same desirability of a sound psychological approach when this can be provided. The suggestions made for conducting a course by the discussion of problems should also be looked upon as suggestions of measures which, by adaptation wherever practical to the conditions of the particular lecture course, can make it more effective in de-

must be adapted to the different conditions. Since there is nothing in industrial situations comparable to the legal definition of issues, industrial situations must usually be simplified and unified before being presented as class problems, so as to confine them to definite factors. Since industrial situations are not precedents, it is usually better to discuss industrial problems on a broader basis than that of the outcome of one particular case.

veloping the capacity of the students to think incisively and practically.

In a lecture-recitation course, as well as in a problem course, there are important opportunities for bringing the material out of the realm of theory and repeatable information, into actual practice. Recitations, exercises and tests need not be confined to mere repetition of the material provided in the lectures and the reading, but can call for original application of this material to engineering and executive problems. Although the problem method is not adopted as a whole, there will probably be times when the discussion or even the acting out of some especially suitable problem can be advantageously introduced. Even the occasional introduction of problems adds a sense of reality to the entire course and keeps the student thinking of the material in practical terms. For, how much value the student derives from a lecture course, as from any other, in preparing himself to embrace the opportunities and to handle the problems that will arise as he progresses in his profession, depends primarily upon how vigorously and thoroughly the course caused him to think.

III. Suggested Psychological Arrangement of a Course in Personnel Problems of Engineers and Executives

The topics listed can be made the subjects of either problems or lectures, depending upon the method of instruction used in the course.

Introduction

The influence of engineering developments upon industrial relations, and the importance of personnel ability in engineering or executive work.

Part I

The Principles of Psychology as they apply to Engineering and Executive Problems

The first part of the course aims primarily to give a sound understanding of the major psychological principles in their

application to industrial situations so that the student will be equipped to use them later in solving well-rounded industrial problems. The cases used should therefore be sufficiently simplified as to bring out clearly the particular psychological principles they are designed to illustrate.

I. *Sources of Ability and Character*

The significance of human traits and the degree to which they can be changed, as illustrated by problems of selecting and securing a job and conversely hiring and testing employees.

II. *Habit*

The acquisition, characteristics, and influence of physical and mental habits as illustrated by problems of methods study, job analysis, and special problems of trade training.

III. *Memory, Attention and Understanding*

The process of memory as illustrated by problems of the acquisition of trade knowledge.

The nature and importance of associations as illustrated by problems of the effect of the working environment upon the working force.

What attracts attention, as illustrated by problems of safety.

Variation in scope of attention and its consequences as illustrated by problems of monotony and strain.

The principles of understanding and the influence of habit on understanding as illustrated by problems of employee and executive stagnation and its prevention by education and educational experience.

The interrelation of habit, memory, attention, and understanding as illustrated by a thorough problem of employee or executive training.

IV. *The Forces of the Personality*

Desires and their stimulation, standards and the process of censoring, and the overcoming of self-control by such means as drawing near temptation, fatigue, fear, rationalization,

fixation of attention, and development of escape patterns in revery; as illustrated by problems of employee and executive misconduct and self-control.

V. *Group Behavior*

The influence and behavior of acquiescent and of resistant groups as illustrated by problems of the behavior and management of employee groups.

VI. *Conflict*

The psychology of conflicts between individuals and between groups as illustrated by simplified problems of discipline, inter-departmental friction, or reorganization.

Part II

Dealing with Problems of Executives and Engineers by the Application of Both Practical and Psychological Principles.

In this part of the course problems should be studied as a whole, not as illustrations of some special principle. Accordingly, more well-rounded problems should be selected, and they should be studied thoroughly from all angles, emphasis being placed on the practical handling of the situation. During this part of the course, the handling of problems in class by action instead of merely discussion, is especially important.

I. *Problems of the Engineer as an Employee*

Problems of personal conduct in fitting into his job and dealing with associates and superiors such as those in regard to what a young engineer should do when asked to join a union, when a fellowworker seeks to induce him to curtail output or falsify records, when a superior takes credit for his suggestions, or when he has failed to gain expected promotion.

II. *Problems of Handling Men as an Executive*

Actual interviewing, testing, selling or handling breaches of discipline in class, and such problems as the taking over of

a new plant or department, as illustrations of the principles underlying the executive-employee relationships.

III. *Problems of Wages and Incentives*

Problems arising out of the determination of wage levels, and the application of various forms of financial and non-financial incentives.

IV. *Problems of Internal Organization*

Problems arising out of proper and improper organization of factory functions, as illustrating the interrelation of problems of organization and problems of behavior.

V. *Problems of Industrial Relations*

Problems arising out of irregularity of employment, and out of the absence and the existence of employee representation and of unions, etc.

IV. Suggested Industrial Arrangement of a Course in Personnel Problems of Engineering and Executives

The topics listed can be made the subjects of either problems or lectures, depending upon the method of instruction used in the course.

I. *Introduction*

The influence of engineering developments upon industrial relations, and the importance of personnel ability in carrying on of engineering or executive work.

II. *Problems of the Recent Engineering School Graduate*

(*a*) Selecting and securing a job and conversely hiring and placing employees. (This material may be made illustrative of the broader problem of buyer-seller contacts.)

(*b*) Making a place for oneself and developing in one's work, and its parallel, fitting employees to their jobs and seeing that they progress.

III. *Handling Men as an Executive*

(*a*) The executive task.

(*b*) Problems of working methods and conditions.

(*c*) Problems of wages and incentives to effort.

(*d*) Problems of discipline and leadership.

IV. *Industrial Organization*

Problems of the interrelation of factory functions.

V. *Industrial Relations*

Problems arising out of irregularity of employment, and out of the existence and of the absence of employee representation and of unions.

IV. SUGGESTIONS FOR READING MATERIAL FOR A COURSE IN PERSONNEL PROBLEMS OF ENGINEERS AND EXECUTIVES

This list has been confined to a few outstanding books on each topic. Which books, from this list or the wide range of books published in this field, will be of most value will depend largely upon the character of the individual course.

A well-rounded background for understanding industrial relations and management of men is by no means confined to books directly relating to business and industrial personnel problems. A man's capacity to deal with men is largely measured by his understanding of men and of life. Any reading that broadens his knowledge of human behavior or that causes him to think about life penetratingly, whether it be biography, history, sociology, science, psychology or literature, is valuable background for executive work. With engineering students especially, because of their specialization during undergraduate days, the encouragement of a wide range of worth while reading is important.

I. Management of Men

A. The Job of the Executive

Executive Conduct in Dealing with Men

Craig & Charters: Personnel Leadership in Industry. McGraw-Hill.

E. H. Schell: Technique of Executive Control. McGraw-Hill.

G. H. Lorimer: Letters from a Self-Made Merchant to his Son. Sears.

Foremanship

G. L. Gardner: Practical Foremanship. McGraw-Hill.

C. R. Allen: The Foreman and His Job. Lippincott.

The Responsibilities of the Manager

S. A. Lewisohn: The New Leadership in Industry. Dutton.

S. Webb: Worke Manager Today. (English.) Longmans Green.

B. Personnel Management

Scott & Clothier: Personnel Management. Shaw.

Tead & Metcalf: Personnel Administration. McGraw-Hill.

G. S. Watkins: Labor Management. Shaw.

C. General Treatments of Management

E. D. Jones: The Administration of Industrial Enterprises. Longmans Green.

D. S. Kimball: Principles of Industrial Organization. McGraw-Hill.

II. Psychology of Human Relations in Industry

A. Psychology of Management and Industrial Relations

E. D. Smith: Psychology for Executives. Harper.

B. Psychiatry in Industry

V. V. Anderson: Psychiatry in Industry. Harper.

C. Testing and Industrial Psycho-Techniques

H. E. Burt: Employment Psychology. Houghton Mifflin
J. O'Connor: Born That Way. Williams & Wilkins.
Kornhauser & Kingsbury: Psychological Tests in Business. U. of Chicago.
H. C. Link: Employment Psychology. MacMillan.

D. Psychological Background

F. Allport: Social Psychology. Houghton Mifflin.
J. Dewey: Human Nature and Conduct. Holt.
M. P. Follett: Creative Experience. Longmans Green.
B. Hart: Psychology of Insanity. Putnam.
J. Hunter and others: Psychologies of 1925. Clark U.
W. Koehler: Gestalt Psychology. Liveright.
E. D. Martin: The Behavior of Crowds. Harper.
H. A. Overstreet: Influencing Human Behavior. Norton.
A. Ruckmick: The Mental Life. Longmans Green.
A. S. Tansley: The New Psychology. Dodd Mead.
R. S. Woodworth: Psychology. Holt.

III. Industrial Relations

A. General

J. A. Fitch: Causes of Industrial Unrest. Harper.
R. S. & H. M. Lynd: Middletown. Harcourt.
C. H. Parker: The Casual Laborer. Harcourt.
W. Williams: What's on the Worker's Mind. Scribners.
W. Williams: Mainsprings of Men. Scribners.

B. Employee Representation and Unions

E. R. Burton: Employee Representation. Williams & Wilkins.
P. F. Gemmill: Present-Day Labor Relations. Wiley.
J. M. Hobson: Conditions of Industrial Peace. MacMillan.

R. F. Hoxie: Trade Unionism in the U. S. Appleton.
B. Selekman: Employee Representation in the Coal Mines. R. Sage.
B. Selekman: Employee Representation in a Steel Mill. R. Sage.

C. Profit Sharing

A. W. Burrett and others: Profit Sharing & Stock Ownership. Harper.

D. Mechanization and the Worker

S. Chase: Men and Machines. MacMillan.
H. Dubreuil: Rabots or Men. Harper.

E. Unemployment

W. H. Beveridge: Unemployment. Longmans Green.
H. Feldman: Regularization of Unemployment. Harpers.
S. A. Lewisohn and others: Can Business Prevent Unemployment? Knopf.

IV. Problems and Cases

Harvard Business Reports No. 4. Shaw.
These have some excellent cases as reference material. Most of them are too complicated to be suited for discussion as "problems."
Schell & Thurlby: Problems in Industrial Management. Shaw.
Section V, pp. 235 to 342 gives 33 personnel problems, with test book references.
E. H. Schell: Technique of Executive Control. McGraw-Hill.
This book has some excellent problems of the simpler type at the end of sections.
E. D. Smith: Personnel Problems.
Copies of an unpublished folder of "Personnel Problems" can be procured from the Department of Industrial Engineering, Yale University.

V. Special Reports

The following organizations issue important reports of investigations, or statements by leading authorities, upon the most pressing current personnel and industrial relations problems.

American Management Association: Bulletins.
National Industrial Conference Board: Reports.
The Taylor Society; Bulletin of.

The headquarters of these organizations are in New York City.

Discussion

Sam A. Lewisohn: Well, gentlemen, there is very little for me to add after Professor Smith's brilliant discussion; in fact, discussing his paper makes me feel a little like a bit of insulating material trying to talk after a live wire. It was worth the price of admission and the trip up from New York to hear Professor Smith's analysis of his teaching methods.

His discussion this evening is the culmination of the efforts, as you know, that have been made for a number of years by such members of this Society as General Rees and Dean Sackett and Dean Kimball, Dean Potter, Mr. Hammond, and many others, to have this subject of human relations and labor relations adequately treated at the engineering schools. I am not an educator; I can't talk as Professor Smith talks. I see the necessity of having the students of engineering schools acquire some background in this subject from the point of view of an executive who has seen many men fail to make the maximum use of their opportunity, many engineers fail to make proper use of their industrial opportunities because of a failure to acquire this background that Professor Smith has sketched.

I wonder if you educators quite realize the tremendous responsibilities that you shoulder? General Rees spoke of it this afternoon. As I was thinking and listening to his talk, and that of Professor Smith this evening, I was impressed by the tremendous opportunities that educators have. After

all we executives can only take what you send us. Educators really make the future. I feel I have the answer to the old question of what comes first, the chicken or the egg. My answer would be the educator, because after all he starts the trend of human events. If educators fail to turn out the proper human material opportunities are lost that can never be reclaimed.

As many of you know, I have been one of those who have been most emphatic about the necessity of having some formal course given to your students in human relations and labor relations. At the same time, I agree with Professor Smith that it must be taught with great discrimination by teachers who realize the danger of giving students the idea that the mere following of a certain routine will solve their problems. It is essential in teaching this subject, this very subtle subject in which we are just beginning to feel our way, that intuition be retained. We have lost our natural senses in many directions. For example, we have lost our sense of smell. We don't want to lose our intuitive sense in the direction of our psychological understanding of our fellow men. So in these matters of human relations, it is most important that you don't turn out men who approach the subject too self-consciously, whose whole attitude in these matters will be tinged with affectation. A synthetic personnel manner is not apt to be effective.

As Dean Sackett said to me this evening when I was talking to him, it isn't a subject that can be taught by book. It must be taught by getting the young man to think through the problems of his human contacts. He must at least be made to realize when he gets out in life that he is confronted with a problem in formulating his attitude toward his fellow human beings, particularly when it comes to the handling of labor relations.

I have spoken of the danger of a man becoming too self-conscious in these matters. Well, we have an analogy in the field of salesmanship. I don't know if any of you have been exposed to the blandishments of salesmen who have acquired a sort of a "canned" salesman manner, but in some

cases one feels that salesmen have acquired their art through a correspondence school. It reminds me of a case that I heard about of a young man who had taken a correspondence school course in salesmanship, twenty lessons for twenty dollars, and he had been taught certain stereotyped movements to go through in approaching his prospect. So when he came to his first prospect he put his two fingers, as he was taught, upon the table and he said, "My dear sir, I know how busy you are but I do hope you have a minute for me."

At that the hard-boiled buyer said, "Oh, say, I took that course myself. Don't go any further."

I merely mention that case because there is a danger that if the teaching of this subject is caricatured, if it is taught in a formal manner, more harm will be done than good, and the students will be turned out with a self-conscious attitude toward the whole subject that will make them as awkward as the salesman I spoke of.

As Professor Smith has said, the way you can avoid making the students self-conscious in these matters is by refusing to give them any standardized receipts, any standardized method or answers to these problems, and instead adopting the device of exposing them to the typical situations with which they will be faced in their future life and making them think through such situations.

This is particularly important when it comes to the problem of labor relations. Professor Smith has naturally spoken about the broader subject of human relations. In a way, you can't divide the methods that a young executive must use in his relations with his superiors and with his associates and those that he must use with his subordinates. Yet I have been particularly interested, as you all know, in the problem of the attitude of engineering executives to their subordinates, particularly to the rank and file of workmen, because here we have a problem that is a very, very important social problem, and one that is tinged with dynamite if it is not properly solved.

It is important that students who are taught to think about the subject realize that there is no boiler-made method

of approaching personnel problems; that they will have various different groups to handle; that in some cases slightly different methods must be used from other cases. A different manner must naturally be used in dealing with Mexicans down in Arizona where some four plants are situated, or with the mountaineers of Tennessee, who still speak a sort of Elizabethan English, or with the Slavs, or the Italians. Each group requires a different personnel manner, a different formula. In fact, there is no formula, and we must avoid giving students the impression that boiler-made methods will apply when it comes to personnel problems.

We Americans—and when I say Americans I speak of North Americans—have a head start when it comes to the problem of human relations, for in this Continent of ours we have nothing of the caste system that they have in Europe. This may sound somewhat afield, and yet any observer who goes to Europe is impressed with the fact that the caste system impedes their industrial progress, for there is not that easy camaraderie between employers and employees that we take for granted in this country. It is hard for us to visualize the conditions that still exist, particularly in England, France, and Germany, with regard to the relations between executives and their men.

I was particularly impressed in reading a book on this subject by a French workman named Dubreuil, a very brilliant observer who worked in this country for a year or two in four of our factories. I had the opportunity of meeting Mr. Dubreuil this year in France, and both from his book and from what he told me, I was impressed with the impression he gained of the greater democratic manner that prevailed in this country as compared with that which prevails in the factories of France. He said that he was perfectly astounded at the camaraderie that existed here between the employers and the employees. He particularly comments upon the absence in this country of any of that attitude of patronization that is common in Europe, and particularly in France, where the employer is apt to go up to his employee and say, "Mon brave," in a patronizing way. That may seem a very subtle

thing, but I am convinced that it is something that has been an important factor in our industrial success, the fact that we have not got this caste cleavage to overcome with the consequent resistance on the part of the men.

I regard this whole element of good nature, this natural, easy-going sportsmanship with which we are blessed in this Continent, as something to build upon. It is a subtle thing that should be emphasized, and I mention it as indicating one of the imponderables that you have to teach to your students. An engineer is a natural democrat, and yet within his absorption in problems having to do with inanimate matters he is apt to become aloof and fail to intrude this very subtle element of good nature that makes such a large difference in our industrial relations. I was thinking the other day that it is rather remarkable that there is one element that one never sees discussed in connection with the personnel problem that is a very important factor, and that is the element of a sense of humor. Humor is a very important component of the fine social spirit that pervades both our social and industrial life and it is an essential part of the sanity of the North American outlook. It is something that can be well accentuated.

Only a few months ago I saw a splendid piece of personnel work performed at one of our plants that took into consideration this element. It has been the custom at our plant to give a gold medal to each man, whether he is a workman or a member of the staff who has performed twenty years of service. In presenting the medals the personnel manager had prepared humorous stories about each man to whom the medal was presented, somewhat similar to the approach at a class day ceremony at a college commencement. Some amusing incidents in the man's career, real or fanciful, some takeoff was related, and it was remarkable what a success the meeting was and how fine a spirit it engendered.

This matter of intruding the comic spirit, in a plant, may seem a very unimportant thing as compared to some of the larger problems, and yet it is a very important matter when it comes to maintaining the morale of an organization.

I don't want what I have said to lend the least support to those who maintain that personnel relations are such an intangible, subtle matter that they can't be taught, and particularly that they can't be taught in engineering schools. Nor do I wish to intimate that because we in North America have the advantage of this democratic tradition it is not necessary to go any further. Of course, I believe this subject can and should be taught. We should build upon our tradition, not use its existence as an excuse for neglecting the subject.

As far as the matter of danger of self-consciousness is concerned, you might as well conclude because such games as tennis and golf are difficult to teach, and because there is a danger that when you are taught the game you become self-conscious, that the principles of the game cannot be taught at all, and that formal instruction is useless. Some people who have this notion, particularly in golf, refuse to take any training at all, and their game is execrable. The proper method is to take the formal training and then to allow it after one has consciously gone through it, to become absorbed by the unconscious, and finally the self-consciousness disappears. Similarly a formal training in this subject of personnel relations may possibly create a slightly self-conscious attitude for a short time, but the content of the instruction can finally be absorbed into the man's personality so that when he comes out into the executive field he will be better equipped to handle human relations.

I have spoken mostly about the attitude of executives towards their employees, but let me say that a certain knowledge of modern psychology, of human behavior is a most important advantage in one's relations to one's salaried associates. I was thinking, as Professor Smith was talking, of one executive that is absolutely invaluable to our organization, but a very temperamental individual, a man who did not usually stay with any organization more than two or three years at the most, and whom we now have with us about fifteen years. I can assure you that the reason he has been with us this long is because some of us know a little about

the psychology of human beings and are able to meet his psychological difficulties.

Professor Smith has spoken about several men who have come to his attention, engineers who have failed to reach positions of maximum importance because of their failure to have an understanding of how to handle human relations. Let me say that in my own experience in the last year in addition to cases to which I have called friends' attention, I know of several cases in which men have been turned aside, men with high technical equipment, because of their failure to understand how to handle human relations.

Mr. Owen D. Young, only a year ago at a meeting in New York of a small group, some of you will remember, spoke of the fact that very often his own company was unable to fill important positions of what he called high command in Europe from their own engineering ranks because of the failure to find men with a grasp of broader human problems.

Therefore, I am glad that we have had the opportunity of hearing from a man who has had such practical experience in the industrial field and in the teaching field as Professor Smith, to tell us how this subject of human relations can be taught without the danger of too great formalization, and in a practical way.

Let me, in closing, reiterate that you engineering educators have a very, very important responsibility which you should consider in molding what General Rees referred to as the industrial statesman of the future. I hope you will take advantage of the opportunity afforded to you to make history.

Joseph W. Roe: The talk you have heard tonight is significant. It represents something certain to have a wide influence in engineering education which started some years ago in a conference called by Mr. Lewisohn at his own home, where he put this challenge of training for personal leadership to engineering educators, and this is a definite step toward what he had pictured at that time.

It is evident to all teachers here that there is "something doing" in Elliott Smith's course and that the great asset in

that course is Elliott Smith himself. Without him, his vision, his personality, and his experience, the course would be dead —with these in it is alive.

No subject needs real life more than this and I cannot conceive of such a course as this being taught successfully by a routine teacher even from the reference given in this very course. Mr. Smith brings out clearly that if a student's later experience is relied on only, it is costly, brutal, and haphazard, and its lessons often come too late when the learner has been wrecked in the process of learning. He brings out that the mistakes rarely are clear, and causes are not tied up with the effects often until too late. He, therefore, uses by real cases brought from the wealth of his own experience and his wide contracts to put boys into the situations as nearly as he can reproduce them, without textbooks, to get their reaction and to train a right attitude.

In just this aspect the coöperative system is the greatest adjunct a student can have in connection with such a course as this because the boy meets these cases in his own experience. If he has received raw treatment from a foreman he knows the reactions. This has come out in my own classes. For instance, a coöperative boy one time brought up this case: He had been on an inspection job and had discovered certain faults running in the output. He diagnosed the fault and knew just where it occurred, on what machine, and what was the matter with it. He went to the workman and he pointed it out to him and told him what the trouble was and how to cure it. The foreman came along and bawled him out for doing it. He carried it up to the superintendent. Now here is a problem: which should the superintendent side with, the boy or the foreman? This case was a very real one to that boy.

Anything of that kind, either from experience or from experience through the teacher, which can give these problems to students systematically and get them human-minded, is good. We talk about getting motion-minded. What we want to get is not sentimentality, not the idea in business that it is an eleemosynary institution, but that there are real

human values in there and if I understand Elliott Smith's objective, it is to create an attitude of mind, and with that attitude of mind sound, then the real experience from the outside is going to be obtained at less cost, with greater effectiveness, and much sooner. If this can be brought about for industry, it will be a gain for the boys and it will be a gain for the school.

President Rees: There are just two points I would like to comment on in Professor Smith's very excellent paper. The first is with reference to an experience in industry. Before the war a few far-sighted companies were taking an interest in personnel work, and in human relations in industry. This personnel work expanded tremendously during the war, and we had so-called personnel efficiency experts who came into industry and had formulæ for the solution of all the problems in human relations. I want to pay tribute, however, to a number of intelligent men who attacked this problem with an open mind and contributed greatly to the difficult human problem that developed during the war. At the close of the war industry was not convinced of the value of this human relations problem in business, and as you all witnessed, during the depression of 1920 and 1921, many of the personnel activities in industry were abolished or discarded. The most enlighted industries, however, held to a wise personnel policy and kept a personnel staff for the study of human problems. Now the success of personnel work in industry since 1920–21 has been due to the realization that the personnel problem is an operating problem, that those who devote their whole time to personnel work are mostly staff men who serve the line. That means that every man in the operating organization of industry is a personnel man, from the President and General Manager on through the levels of the executives and the supervisory forces, down to the first line foreman.

I simply want to bring that out, that these problems are being met today solely because of the realization that the personnel problem and the problem in human relations is the business of everybody. For that reason I want to empha-

size the importance of engineering students coming to us in industry with an idea at least that there are human problems in industry which are the most important with which he has to deal.

The second point I would like to make is with reference to an impression that I received from Professor Elliott Smith and from Mr. Lewisohn, even from Dr. Roe, that this was too hard a problem for us to tackle. I want to bring that same conception of personnel being the problem of everybody, right down to every individual teacher on the faculties of the engineering colleges of the country. It seems to me that all of the members of the Society for the Promotion of Engineering Education sense the tremendous importance of human relations in industry, and the importance of helping our students to an appreciation that there are such problems. This appreciation should stimulate each individual teacher, whether he is teaching drawing or thermodynamics, or some of the many courses in electrical engineering, to pause every once in a while in the technical problems he is presenting and indicate that right in this and its application, in the actual experience of the student in the future, there is likely to be involved a human problem.

While we must have brilliant men who have devoted their life's attention to this matter of human relations, like Professor Smith has done, we don't want to make this too hard. We can all contribute, and then in addition, wherever it is possible, organize the kind of a course that is indicated in Professor Smith's most excellent paper. But let us all remember that this is an operating problem, that you have an operating problem on the campus, in your classes, in your laboratories, in your drawing rooms, in your evening classes, and in all your work, to emphasize that after all the most important problem in business today, as I said this afternoon, is that of human relations.

Professor Roe: Elliott Smith is a pioneer in this work. What do we want to gather from his experience? We should ask ourselves several questions. In the first place, is this type of training needed and worth while? In the second

place, shall we go into it? In the third place, what is the first step? It is not to get a textbook and put such a course in the catalog, but to select and train the right kind of man to do the work. That is the first and most important element. You probably have, as Professor Williston has said, men in your faculties who have this spirit. Any man who worked under, or was taught by L. P. Breckenridge, knows what is meant. If you have any man with that kind of spirit he is the one to take leadership in this kind of a field. I think it can be done. The essence of what we have in mind is to develop in engineering students by the time they graduate, whether in our own work only, or with the help of cooperative work, a certain attitude of mind not only toward workmen but toward their equals, and toward their superiors, which permits growth and development through experience later.

INDUSTRIAL RESEARCH METHODS AND WORKERS*

EDWARD R. WEIDLEIN

Director, Mellon Institute of Industrial Research, University of Pittsburgh

In giving me the honor of addressing this distinguished society, you have selected a very appropriate city, Montreal, as I am in the field of research developed through the influence of a Canadian, Dr. Robert Kennedy Duncan. Dr. Duncan was born and raised in Brantford, Ontario, received his education in Canada and the University of Toronto, and came to the United States to teach us how to educate industry to appreciate the value of science. In March, 1911, Dr. Duncan inaugurated the Industrial Fellowship System at the University of Pittsburgh in the Department of Industrial Research, known since 1913 as Mellon Institute of Industrial Research. The system was first established at the University of Kansas in 1907, and the two units were united in Pittsburgh in 1912. It represents a sane, practical plan of coöperation between industry and learning for increasing the efficiency of American manufacturing. The success of the Institute today is due to the sound fundamental principles established by Dr. Duncan.

The present home that we occupy was completed in 1915. It was started by Dr. Duncan. Unfortunately he never lived to see it completed. When we moved into the new building in 1915, there were 21 Fellowships in operation, employing 32 Fellows, and industry was contributing $61,200 a year for the support of the work. On February 28, 1930, at the close of the Institute's fiscal year, there were 61 Fellowships in operation, employing 142 full time Fellows, not including a number of assistants and permanent members of the organization, and industry contributed $929,109 for the support of the work. We have completely outgrown our present quarters. You have probably noticed the press reports of our new temple of science which will be erected in Pittsburgh to house properly the Fellowship work of the Institute. Construction work will be started early this Fall.

The nation-wide increase in research, as evidenced by larger budgets for investigational work, is reflected in the rapid growth of Mellon Institute, one of the oldest institutions in the country organized exclusively for the application of science to technology, and is likewise emphasized in other research organizations. In 1900,

*Presented at the annual dinner of the Society at Montreal, June, 1930.

the number of organizations devoted exclusively to research work in the United States could be counted on the fingers of one hand. There are at the present time over 1,000 well established research organizations, and during the past year industry spent around $235,000,000 for the support of these research laboratories. It is being made clear to American manufacturers that scientific research, properly planned and systematically carried out under conditions favorable to productive effort, is remunerative to them and actually constitutes an investment. We, in our organization, do not derive any profit out of our investigations, and only survive as a result of our achievements. Our position is well illustrated by the boy who was hoeing potatoes in a garden. A man came along and said, "Son, what do you get for doing that?" His reply was "Nothing, if I do, and the dickens, if I don't." That expresses our own position.

It is now recognized by industrialists that the methods of science are the most effective procedures thus far developed for the advancement of technology, and that, therefore, scientific investigation is an essential economic adjunct to manufacturing enterprises. But this understanding of the meaning and value of research has come in quite recent years in these United States, for American manufacturers required demonstration of the economic value of scientific investigation. At present the encouragement of research and the recognition of the desirability of disseminating the knowledge gained are indeed among the most noteworthy signs of progress in technology.

Industrial history makes it clear that happy ideas and chance discoveries have not contributed materially to the progress of technology. The stimulus for development generally results from demand, and in manufactures organized on modern lines the working out of new processes and the improvement of existing processes consist mainly in the application of scientific fact and theory, the raw material of the applied scientist and engineer. Industry, therefore, should sustain pure as well as technical research, not merely for altruistic reasons, but because pure science research makes for progress in technology. This was recognized by President Hoover as a huge national need, while he was Secretary of Commerce, and a campaign was started to raise an adequate fund to support pure scientific research work. The fund has now reached approximately $10,000,000 through the efforts of a strong committee of outstanding scientific men, under the auspices of the National Research Council. It is not only important to hold such capable men in our universities to supply the raw material, pure scientific data, but also to have these men available to develop new talent and to supply industry with the other essential raw material, the well trained research worker.

Industry requires men well trained in the fundamentals of science and most important of all, men who can think, and think clearly. A teacher should be an inspiration to his students and should point out clearly the future possibilities in the field of science, and not teach them in such a manner that the student will get the impression that everything worth while has been accomplished. Dr. Duncan possessed that characteristic to a very high degree. I entered the field of chemistry owing entirely to the manner in which he taught the subject. At that particular time he pointed out to his classes in the most glowing terms the rainbow, at the end of which you would always find a pot of gold, and many of his former students have achieved that distinction. Dr. Redman, another Canadian, and former Fellow of Mellon Institute, is a good example. One of the most important constituents of radio equipment is a chemical product known as "bakelite" or "redmanol," which is manufactured from two common substances, namely, carbolic acid and formaldehyde. Dr. Redman has played a most important part in evolving the technology of the phenol resins. Beginning with the discovery of a proper method of controlling the production of these phenol resins, their subsequent hardening under heat and pressure, and their increased strength when fillers are used, particularly fibrous fillers, all this has made possible their application in technology in the widest and most varied manner. It has made possible the rapid and cheap production of distributor heads and rotors for automobile ignition. The accuracy of dimensions with which these phenol resins can be molded and their permanence of shape under elevated temperatures, such as one gets under an automobile hood, have made their application very extensive in the automobile industry. They become coil housings, bells for motors, insulation strips, and punchings of all sorts and varieties in the automobile today. Also, the timing gear in many automobiles is made of laminated canvas-base phenol-resin material.

Phenol resins are rapidly changing the grinding wheel and waterproof sandpaper industries and bid fair to revolutionize completely the method of oil-well drilling, since carborundum, held together with a phenol resin, cuts through sand many times more rapidly than steel bits.

Some of the more spectacular and less voluminous uses created for phenol-resin products are dentures, non-heat producing grinding instruments for the dental trade, glaze for porcelain ornaments, handles on coffee percolators, pencil barrels and fountain pen barrels, beads, buttons, billiard balls, and pipe stems.

Chemistry, the eldest of the experimental sciences, has contributed a great deal to the development of research, but it remained for economics to show the need for and value of industrial research.

As early as 1890, the opinion was expressed in England and on the continent by chemists who reviewed the trend of developments in their science, that the greatest advance in future years would take place in America. Although European countries stood in the forefront at that time, it was felt that conditions were such in America that we were destined to take the lead at a not distant date in both industrial and scientific achievements. This prophecy has to a large extent been fulfilled. For many years the German chemical manufacturer was far in advance of those of all other nations in recognizing the utility of industrial research; but during the past decade American technologists have assumed leadership in employing highly trained chemists and other scientists in original researches with a view to new discoveries or to useful improvements. The United States now has the largest chemical industry in the world, and this position has been attained through coöperation between aggressive capital and creative science. This type of research coöperation reduces to a minimum the time elapsed from the discovery of a principle in science to mass production. The electrical industry, which is based upon the pure science research of Michael Faraday, required nearly a hundred years for its development. Compare with that the development of the radio industry or any of our other modern branches of manufacture during this period of better understanding of coöperation among the pure science research worker, the industrial scientist, and the industrialist.

The round-the-world cruise of the Graf-Zeppelin was made possible through scientific coöperation. The past decade has witnessed the rapid rise of a new branch of the organic chemical industry, and two of these products were used to refuel the ship. Ethane was used to refuel the Graf-Zeppelin in its recent trip to this country, and we supplied its fuel requirements by shipping propane to Japan and California for the world cruise. In Japan a hydrogen-propane mixture (one-third hydrogen) and in California a natural gas-propane mixture (50–50) were taken on by the ship.

The rapid development of chemical research has made progress necessary in many other fields. The automobile is a good illustration of this fact. If we stop to think, we shall realize that all the resources of a vast and complex civilization have been called upon to produce the car of today. The motor-car industry not only has taken full advantage of the possibilities of its own research organizations, but its spectacular expansion has given impetus to other classes of industrial research, such as petroleum products, rubber, metals, leather, synthetic fabrics and compounds, as well as road materials.

Until thirty years ago, petroleum was important to civilized man chiefly because it was his main source of light. Kerosene lamps

are still widely used in the Orient and the other far places of the earth. Here, however, we get our light by more efficient means and use the petroleum to supply another vital need, a fuel for our automobiles. Studies in the cracking of oil have doubled the available supply of gasoline and promise methods for completely converting crude oil into motor fuel with a little by-product coke. Motor fuels with anti-knock properties have been developed. We hear a great deal about the possible exhaustion of our petroleum resources, and this is one of the reasons for the maintenance of chemical and physical research on petroleum production problems, to provide for such an emergency. This has created a new field of research for the engineering profession. Many scientists have been employed in the refining field, but the production of crude oil, until recently, had changed very little from the first methods used when oil was discovered in Pennsylvania. Great advances have been made in the location, production and transportation of crude oil, since science has been applied to this branch of the industry. The Germans are now concentrating on the production of heavy oils from coal, and have made sufficient advance to enable them to construct a unit of commercial size. It is rumored that Germany will be able to produce sufficient motor fuel to meet its own requirements.

The rubber used in the automobile tire has likewise developed some of our largest corporations, and one has only to recall past experiences with an automobile tire and then think of the present-day product to appreciate the advances that have occurred in this industry through the application of science. The service life of tires has been greatly increased, thanks to research on accelerators for vulcanization, on rubber compounding, and on the tire fabrics.

Progress in other and related fields not so well known has been equally rapid. The automobile has completely revolutionized the paint and varnish industry, because of the requirements for a better finish and one that can be applied in a short period of time. The result is the manufacture of nitrocellulose lacquers, and the development of new synthetic gums and solvents. This, in turn, has created two entirely new industries within the last ten years. One of these industries is located in the corn-belt area of Indiana and Illinois. Through scientific research in the field of biochemistry, the corn is treated with a new type of microörganism which produces these necessary lacquer solvents instead of the familiar solvent, ethyl alcohol. The second of these industries depends upon the common product, natural gas, for its source of raw material. This industry is especially close to us, as it originated and was nurtured into adolescence in the laboratories of Mellon Institute. The results of this research have made available in large quantity and at low cost a variety of commercially valuable organic chemicals,

distinct in origin as well as in application from the synthetic chemical products heretofore generally known.

A principal product of these efforts is ethylene glycol, which has come into commerce for the first time, after having been known since the early days of chemistry only as a curiosity. Ethylene glycol is now widely used in explosives manufacture and as an anti-freeze material for automotive engines; it is also finding numerous new uses to supplement the inadequate supplies of glycerin and is serving purposes entirely new in the arts. The ethers of glycol are ideal solvents for nitrocellulose lacquers, and in the rapidly expanding lacquer industry they are introducing indispensable qualities.

The pure hydrocarbon constituents of natural gas have also found many valuable and interesting uses. For example, ethane, propane, isobutane, and normal butane have been found to possess special physical properties that make them desirable as refrigerating gases. Commercial propane, distributed in cylinders, is a fuel gas with widespread application in the household, laboratory, and factory. Thus, ever more products are being made from natural and other gases, and it is apparent that an industry of large proportions is in the process of being established on the fundamental research that has been conducted in this field.

The electric illumination, radio, electrochemical and telephone industries have been developed from their basic inventions to important places in our present industrial organization in a period of less than fifty years. In each there is striking evidence of the interrelation of the "cycle of research" with the various stages in the evolution of the industry. It is significant that the time lag in the development of these industries has been greatly reduced by systematic scientific research. What happens when research is undertaken in older industries—in the iron and steel industries, for example, which are of the oldest in recorded history? The steel industry for hundreds if not thousands of years was an art, and yet within less than 50 years it has felt the influence of research and has experienced a greater development in that period of five decades than in all the centuries that went before.

Another very important manufacture that has been due mostly to chemistry is the byproduct coke industry. Modern civilization rests largely upon coal and iron, which, in turn, are linked by coke. In making coke, other materials, termed byproducts, are had, from which modern chemistry has developed thousands of indispensable chemicals, fertilizers, explosives, disinfectants, perfumes, roofings, wood preservatives, medicines, and practically all the dyes used in the textile industry.

Naturally, one of the main subjects of research is coke itself. Not many years ago, the coke made in the wasteful bee-hive oven

was preferred by the average blast-furnace man. Now it is generally recognized in American practise that byproduct coke gives superior results. This has been due not merely to a change of attitude on the part of the blast-furnace man but to a real improvement in the quality of the byproduct coke; and research is in progress for further improvements of interest in blast-furnace practise. Frequent investigations have to be made in relation to producing the best possible coke from new types of coal. These coals must be studied both in the laboratory and in the plant, in order to determine the conditions best adapted to each. The conditions satisfactory for making coke from one kind of coal may be quite different from those necessary in dealing with a different type. The results of these investigations are of the utmost importance from the standpoint of fuel economy and conservation.

Coal is one of our most important raw materials, and offers many opportunities for research work both from the chemist's and engineer's viewpoint. In the field of engineering and physics, heat insulation in all its varied aspects has a great future, since it has recognized value in reducing working expenses, and specifically it is of very material aid in effecting fuel economy. It is recognized generally that the losses from bare pipes and boilers are considerable, but the real magnitude of these losses is little appreciated. The fact that the loss from 1,000 sq. ft. of exposed surface at 100 lb. per sq. in. steam pressure represents over 300 tons of coal annually is a sufficient justification for the serious consideration of the subject. Valuable research has been conducted in this field during the past few years, which has placed the industry on a scientific basis and has created more efficient, durable and serviceable insulation. The proper amount of non-heat-conducting material which should be applied to any heated surface will be that at which the cost of an increment of the covering will just balance the savings that will be accomplished by the increment. All insulation companies are now in a position to supply such information as a result of careful scientific research work.

One of the biggest problems that we are facing is the smoke nuisance. Smoke does not have a single saving grace. It is injurious to health. It is expensive in that it means fuel waste, high laundry bills, defacement of expensive buildings and lessened working capacity. Experts declare that throughout the United States smoke costs each inhabitant $16 annually. Smoke is not, as it was once thought to be, the inevitable consequence of industrial and commercial activity. Modern power plants do not smoke and neither do privately designed heating plants in capable hands.

The remedy is to provide such engineering oversight of new installations as to insure a non-smoking plant to begin with. This

can be done. It may mean changes in building plans, a larger investment, a greater responsibility of management, a more intelligent operation, but these things are the price of clean air. It is of little use to complain of smoky stacks and allow new ones to be added daily.

Along with coal, we have another most important raw material in cellulose. An enormous chemical industry has been constructed on the use of this raw material, including lacquers, explosives, celluloid, sausage casings, and last but most important rayon. Rayon, born of chemistry, is now an important factor in the textile field. Many manufacturers are at present making all-rayon fabrics, while others are combining rayon with cotton, silks or wool. About one-fifth of the hosiery produced today contains rayon; millions of yards of cloth are being made annually, either wholly or in part of rayon. Cellulose is also the basis of another new industry developed in the chemical laboratory, the artificial sausage casings. One hundred miles a day of these casings are now produced to cover our well known "hot-dogs." As is so often the case in the synthetic production of a new product, new properties are introduced which give added value to the material. It is possible to remove these synthetic casings from the meat—after the stuffing process—and the finished weiner is sold as a skinless product.

Someone has said, "the sugar industry without the chemist is unthinkable." This statement is indeed correct, for chemistry has been the main factor in the development of sugar technology. Agriculture, manufacture, refining and uses have depended upon chemistry in this important industry; and the many processes the chemist has worked out have brought better, cheaper sugars and growth to all branches of the sugar producing and consuming manufactures.

The manufacture of glucose and grape sugar, or the corn products industry, was built upon a notable discovery of a chemist, namely, the conversion of starch into reducing sugars. Since then—over a century ago—chemistry and chemists have been inseparably and intimately connected with this great industry. Chemical research has shown how to make profitably corn syrup, starches, dextrins, many gums (for adhesive purposes), various sugars, gluten feed, oil, oil cake, and other products from corn. The chemist, in fact, has found the way to manufacture over one hundred useful commercial products from this raw material, the fruit of a majestic, wondrous plant.

The problems that are now receiving the most attention in Europe as well as in the United States are the fixation of nitrogen, coal liquefaction, gas supply, dyestuffs, synthetic organic chemicals, principally solvents, and textiles, including artificial silk. In

Europe most of these problems are related to and depend upon coal or lignite as a raw material. From coal can be made synthetic ethyl alcohol, methyl alcohol, other organic solvents, and hydrogen for use in the nitrogen fixation process for the manufacture of ammonia, besides dyes, medicinal products, motor fuels, and fertilizers.

The countries of Europe are also combining forces in the development of these various industries. This type of coöperation cannot help but bring important economic results, and yet it is only one part of an effort to gain industrial and independent recognition.

Europe realizes that scientific coöperation is the most powerful means of dealing with many of the economic difficulties with which it now is faced, and the surest means of self-protection and preservation. This is also regarded as true in all well-organized business enterprises of today. The aim of business is profit, and hence it is essential to operate plants with gain. In consequence of this recognition in industry, incumbrances that interfere with advantageous production must be discarded. Waste, inefficiency, senile processes, antiquated plants, and unscientific practises in general are the foes of profitable operation. Effective intelligence service on market conditions, both foreign and domestic, and adequate technical research on plant production problems are the agencies upon which the dynamic, successful business of today is most dependent.

Today's strenuous competition most influences progressive change or improvement. It has brought respect for industrial research, simplified practise, efficiency programs and statistics. Paradoxically, associated effort has effected beneficial contact among competitors and has enabled concerted vigilance, fact-finding, and progress in technologic and market research.

It has become a truism to say that scientific research has exercised a profound influence on industry, particularly upon the character and direction of manufacturing methods. It is equally true that industry has had a great influence upon scientific research. By providing opportunities, industry has led to the improvement and extension of research procedures.

Business is being conducted on a wider scale and at greater speed than ever before. This makes it hard for the weak and inefficient manufacturer, but opens a wonderful vista to those who are strong, able, free from over-worship of precedent, and appreciative of the possibility of improving on the methods of the past. Modern business therefore is especially receptive to the application of science in the correction of production, advertising and sales troubles.

Formerly, throughout much of industry, the voice of the scientist

was that of one crying in the wilderness. Now he commands the respectful attention of the man in the street, as well as of every manufacturer.

If one attempted to appraise the value of science in dollars, the figure would be inconceivably large. Science can best be measured, however, in terms of human achievement, the mastery of the forces of nature, the elimination of poverty and disease, the prolongation of life, the advancement of learning, the growth of right living and sound thinking, and of good understanding among men.

But for all of the benefits that she has conferred upon the world, science asks only that she be provided with an opportunity for her faithful workers to multiply their efforts in behalf of humanity. Pointing to the past, she holds forth with certainty the promise of further greater truths and their developments, new agencies for the comfort and convenience of mankind.

THE ENGINEER AND FINANCE

By WALTER WILLIAM COLPITTS,

Consulting Engineer, New York City

It always gives great pleasure to graduates of McGill to return to their Alma Mater for any purpose, but it is particularly pleasing to come back as a guest of the University to attend a function of such importance as a meeting of the Society for the Promotion of Engineering Education. It is also a matter of great satisfaction to me to be one of those to welcome to McGill the delegates from that great school, L'Ecole Polytechnique de France. Indeed that opportunity is furnished us entirely too infrequently.

As engineers you have all had the experience, no doubt, of seeing the source of a great river, and have followed the tiny trickle as it wound its way through the mountain gorges and out onto the plains, augmented by streams from other sources, growing larger and larger until it becomes a mighty river and a main artery of commerce.

The engineering profession might be likened to that river. Its genesis was in the work of a few men who built bridges, took a little ore from the ground, or planned engines of war. Down the ages, as civilization advanced, they gained a little in knowledge and scope, but it was war that gave them their main opportunities. The stream was still small until the advent of the railroad in the early part of the nineteenth century, and it was in the great events of that period that the civil engineer, as distinguished from the military engineer, was born. Then indeed, in the early stages of the development of our great natural resources, the stream became a small river, and now in the twentieth century with almost every sort of undertaking turning to the engineering profession for advice and counsel, the river has become a mighty torrent carrying civilization along at tremendous speed.

In fact, the word "engineering" has come to stand for so many types of activities that even members of the profession are astonished at the multitude of them. From the grand old profession of military engineering, the daddy of them all we have branched out in every direction. In Canada and the United States, perhaps more than in any other countries, we have come to rely so much upon our engineers that they are now carrying a tremendous load of responsibility that steadily grows heavier. Almost every large busi-

ness to-day avails itself in some manner or other of the trained assistance to be given by the members of our profession in the solution of their technical problems.

The growing relationship between engineering and finance is, I think, the latest development of all, but the difficulties in the way of bringing about such a relationship have been very great and progress has been slow, I think, largely on account of the attitude of the engineer in failing to gain a knowledge of the principles which govern business.

Prior to the time when we began to build our railroads, practically all great works were built by governments, financed by governments, and conducted by military engineers. There were no problems of economics such as we know them today. Financial problems had to do principally with answering the question as to how the money could be found to carry out a project, and the usual solution was to levy an additional tax on an already overtaxed people.

Even as late as fifty years ago people generally would have said that there was no closer relationship between engineering and finance than between the trade of the carpenter and the business of the money lender, and in the intervening period, indeed until very recently, the paths traversed by these two great professions, engineering and finance, have been quite divergent.

I well recall an experience of my own when, as a young man, I was the chief engineer of a western railroad, which was largely owned in England. After giving considerable thought and study to the company's financial condition I became convinced that the president of the company himself did not realize that drastic measures must be taken to avert a receivership. I broached the subject to him and in particular stated my belief that unless we were extremely careful there would not be sufficient funds to pay the forthcoming installment of interest on the bonds. To my utter astonishment I was threatened with decapitation and told never to undertake to discuss a financial problem with him again; that I would do well to confine myself strictly to my engineering work because he had never known an engineer who knew anything whatever about finance.

The sequal to that experience is interesting and to the point. The road was thrown into a receivership and I resigned my position and joined my present partner in the establishment of an engineering firm in New York. The British interest in the road was finally placed in my hands to dispose of in any manner that I saw fit, and after several years of nursing the road was finally sold to a western trunk line for a good round sum.

As a matter of fact, I think the engineer of the past came by his reputation for being devoid of financial sense quiet honestly. Many

of the great fortunes of the country, as well as many of the great industries upon which our present day civilization rests, are the product of his brains, but the translation of his ideas into profitable business enterprises has mostly been the work of others. And the reason for this is plain. The engineers of an earlier day, and to a large extent of this day, were engaged in work that removed them far from contact with men who know anything about financial affairs at all. The technical work for which they had been trained absorbed their entire attention. Even those who were fortunate enough to have had a college education had not been initiated into the mysteries of finance and they were quite uninterested in the subject. They were admired by the men in whose hands the financial problems of the enterprise were placed for their willingness to undergo hardship without complaint, to find ways across the trackless prairies and through seemingly impassible mountain ranges, and for their cunning in turning the forces of nature to the uses of man; and I have often wondered why in all these years so few engineers have aspired to themselves promote the enterprises that depended so much upon engineering skill. We have been inclined to feel that financial acumen is only another name for a highly developed bump of acquisition, and as a consequence we might be likened to the cooks who are not invited to eat the excellent dinners they prepare.

Perhaps the shortcomings of the engineer in this respect are due to the fact that as a young man his work of necessity is confined to the technical phases of the enterprise, while the financial problems are solved by older heads, and perhaps also the business phases of the enterprise on which he is engaged do not interest him. He likes to deal with the forces of nature because nature always plays fair. Under the same circumstances nature invariably performs exactly the same. She never deceives and the engineer can always take her at her word. She never dissembles, compromises, bargains, or trades, and she always pays in gold coin. And so I think the engineer, in the course of his professional work, learns very early to take nature at her face value, and quite properly so. But my experience in the realm of business leads me to believe that if financial transactions were conducted on the basis of face values there would be many more sorry people in the world than there are, and engineers, I believe, are as well, if not better, equipped than any others, if they would apply themselves, to display the lights on financial shoals.

Yet I have known engineers to conduct their work with most painstaking care and to leave no stone unturned to insure the construction of a safe and adequate structure and then, without any investigation whatever of the merits of the business itself, to accept

pay in securities which later turned out to be worthless. I have done it myself, and without pointing any accusing fingers I fancy a good many of you have done the same thing.

Engineers are analysts by training, and both in the design and erection of engineering works of all kinds are required to practice the art of the diagnostician to a marked degree. The engineer is continually observing the relationship between cause and effect and acting upon his conclusions with a sure step. To my way of thinking, his training and mental makeup are most valuable equipment when devoted to the solution of business and financial problems, and I feel quite strongly that the more general extension of his work in these directions will not only be of advantage to industry and the public generally, but will tend markedly to further his own interests.

As a matter of fact, there are few business problems that escape solution under reasonably accurate analysis, and if the analysis is carefully conducted, without bias, and if full weight is given to each element of the problem, it is astonishing how correctly a future course of action may be charted. Nowadays business is largely run by charts. Future trends, the bearing of one factor on another, the time when certain actions should be taken, all can be foretold from properly constructed charts. The business executive no longer has to guess what course he should pursue; to a very large extent his charts, prepared by unbiased analysts, are his guide. But charts are the engineer's middle name and he is schooled in his technical work to be unbiased. Having the technical training which enables him to know what is practicable and what is impracticable from the physical standpoint, and being familiar with the processes of deduction which are used in engineering investigations, he should be readily able to adapt this knowledge to business investigations and so serve his employers or his clients in a dual capacity, and serve himself in the investment of his own funds, in which latter respect he has in the past been woefully deficient.

My contacts in the business world lead me to believe that there are distinct signs of a tendency on the part of business men to utilize more and more the experience and knowledge of the engineer in the solution of purely business problems. The old trial and error methods of starting new businesses and of conducting old ones are gradually giving way to the far more logical method of careful investigation. The large banking houses in Canada and the United States are learning from experience the value of full engineering advice concerning the projects they contemplate financing, and this advice pertains not only to the physical elements involved but extends to the question which is most important from the standpoint of the investor—that is its merits as a business

undertaking. The growing demand for engineering service of this character furnishes the opportunity for widely extending the field of usefulness of the engineer in directions which a few years ago would have been considered wholly illogical.

May I say a word about the character of my own practice to indicate more specifically the trend of the relationship between engineering and finance as we see it in our own shop? The work of our firm, as well as that of other firms similarly engaged, is ordinarily of a confidential nature, and therefore I will refrain from using the names of corporations or individuals. Although the work of other firms is also largely confidential, we sometimes find it necessary to know what they are doing. Nevertheless, I don't suppose I would be justified in speaking of the work of our competitors. In discussing our work I should first explain that every member of our firm, and practically every member of the staff, is an engineer by training and experience.

We are truly amazed at times at the variety of problems that are brought to us, problems that on their face would seem to have no relationship whatever to engineering. For example, we once helped a theatrical company to decide what it should do about the movies, and in another case we were asked by a movie company to advise what it should do about the talkies. It was left to us on another occasion to decide whether a chain grocery company should go into the candy business.

We have been called upon to help foreign governments with their physical and financial problems. We have taken railroads through trying periods of their development. In one case a large railroad company that was in serious financial difficulties was saved from receivership through the position we took, after thoroughly studying the circumstances, that the company would respond to sympathetic treatment, and it is now a prosperous road. We have made surveys to determine why the selling policies of companies manufacturing specialties did not produce more satisfactory results. We have studied the problems of a great variety of other businesses—sugar, steel, public utility, airplane, automobile, and many others.

At the moment we are trying to decide whether a bridge should be built between two cities separated by a large body of water; whether a company owning a large sugar plantation should refine and market its own product; whether the rates to the various docks in New York Harbor are on an equitable basis; whether a railroad on an island in the Caribbean should be built; whether a railroad should belong to one group or another in the plan for consolidating all of the railroads of the United States into nineteen systems; whether a company manufacturing a product in general use should consolidate with the company that furnishes the raw material; and

a variety of other questions. But I think perhaps the easiest question we have ever had to answer is one on which we are now preparing to give testimony before a court. Two large companies are proposing to consolidate and we are asked to state whether, in our opinion, they should engage engineering service in working out the basis of exchange of stocks.

We find in our practice that just as fundamental engineering principles are much the same, whether we are designing a bridge, a building, a dock, a mill, a power plant, or whatnot, the underlying principles of finance are applicable in a general way to businesses of every description.

I think perhaps in our own practice we have rendered as valuable service in preventing our clients from financing unjustified projects as in any other respect. I should say that scarcely a day passes that we do not turn thumbs down on some business venture. We have approved the construction of a number of toll bridges throughout the country, some of them very important structures, but we have disapproved many more than we have approved. In one case, so insistent was the promoter of a small railroad that the project had extraordinary merit that four separate banking houses whose interest he had enlisted asked us for our opinion on its possibilities. How many other engineering firms disapproved of the project we do not know.

I hope I will be pardoned for referring in this general way to a few items in our own practice. I have done so only to illustrate more concretely the width of the band in which the two professions are beginning to function together, and to indicate the extent to which this band may be broadened.

And, gentlemen, I can assure you there is nothing monotonous or dull about the work that is entailed in this growing relationship between engineering and finance. It is a new story every day and the sport of tracking the elusive dollar to his lair in the applications of engineering science to business is at times full of romance.

I verily believe that much of the suffering that has resulted from such extraordinary occurrences as the stock market debacle of last autumn and the business depression which we are now enduring might in large measure have been alleviated by the dissemination of authoritative economic information concerning our principal industrial activities by a permanent fact-finding body composed of engineers, economists, and financiers. I do not say that such things could be prevented by any human agency but it seems apparent now that ignorance of the economic forces that rule over business affairs on the part of a large proportion of the people has been a strong contributing factor in producing the swirls of business sentiment that so often engulf us, and if we are to proceed on a more even

keel in the future it must be through the gathering of more comprehensive data concerning economic conditions that the engineer ought to be well equipped, first, to bring together, and then to read and understand and explain for the benefit of all.

In conclusion, I want to say just a word about the engineering training that is given at McGill. The Faculty of Applied Science under Dr. Mackay, and under Dr. Adams and Dr. Bovey before him, has always maintained the highest standards of education and has kept McGill in the front rank of the engineering schools of the continent. The men who have taken their training here in any department of the university and are now practicing in the United States all can testify to the fact that they put in a good word for themselves whenever they say, "I am a graduate of McGill." It is the proudest thing I am able to say about myself, and in saying it I invariably arouse a note of interest. Through Sir Arthur Currie's wise guidance the university maintains a reputation second to none on this continent, and the fact that so many students from the United States are attending McGill is outspoken testimony of the manner in which the courses given here are regarded south of the border. I am sending my own children to McGill and the one here now is, I think, the most enthusiastic student in the University.

I believe I have never attended a convention that I have felt so responsive toward as I have this one. It seems to me that the proceedings of this evening have been most unusual, most interesting, and should be productive of the greatest good to the engineering profession. I have watched the work of the Society for a good many years, and I have felt that it was broadening the scope of the engineer, and particularly that it was broadening the views of teachers of engineering to the end that our work may become increasingly useful to the public at large. I congratulate you upon a most successful convention.

THE HISTORY OF THE FLEXURE FORMULA *

By H. F. MOORE

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The Historical Importance of the Flexure Formula. Historians are beginning to give tardy attention to the importance of the work of the scientist and the engineer as a factor in human progress. The reason that such recognition has been tardy is not far to seek. The writer of history has generally lived either in an atmosphere surcharged with military and diplomatic interests, or he has been trained only in the so-called liberal studies, and the works of poets, prose writers, artists and abstract philosophers naturally are *the* important things in the world as he sees it.

However, the modern historian probably owns a motor car, his wife has her domestic laboratory equipped with an electric refrigerator and an electric washing machine, and the importance of engineering comes to his attention through the humble back door of domestic operation if not through the dignified front door of his professional contacts. He has made a good beginning towards recognition of the great transformation of human life by pure and applied science, but as yet he has observed mainly the dramatic features of this transformation—the steam engine, the dynamo, the airplane—and has not yet paid much attention to less striking, but equally important, phases of this transformation.

One such undramatic field of development is found in the problems connected with the strength and stiffness of structural and machine parts. No structure however beautiful in design, and no machine however ingenious in its general scheme of operation, can function successfully if it will not carry its load without fracture. An old ruin may be beautiful; a new wreck is *not*, nor is a propped-up beam or arch, nor is a broken car axle. Today scientific advance in the fields which require the use of high temperatures meets its main obstacle in the lack of metals that will withstand the desired temperatures without failure.

The general scheme of designing structural members to carry direct tension or compression has always been practically self-evident. The load which can be carried is obviously proportional to the area of cross-section of the member under load. But when

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flexure-carrying members are to be designed the general scheme to be followed is by no means self-evident. Evidently *span* is a vital factor, and mere area of cross-section is not a guarantee of flexural strength. The ancients failed signally to develop, or at least to record, design methods for beams and girders, and were never able to build structures involving long spans. They developed the arch, which involves compressive stresses, and which is the easiest span-stretching structural member to design by rule-of-thumb methods (and the hardest to design by careful computation), but did not develop the girder. One outstanding reason for this failure was the attitude of disdain for experimentation manifested by the learned world of Greece—a looking down on the "mean and manual labor" of experimentation as something quite beneath the dignity of a scholar and a gentleman. In this connection it is only fair to state that the great Aristotle did not share this contempt, but that Archimedes, the father of engineering, was so affected by it that he adopted an humbly apologetic attitude towards his own great engineering achievements.*

It was not until the time of Galileo that experimentation obtained general recognition as a legitimate instrument to use in the search for truth, and it was Galileo who started the modern study of strength of materials. The development of this study has centered round the development of the common flexure formula $M = SI/c$, to use the symbols of Merriman, the formula familiar, in form at least, to every undergraduate engineering student above the sophomore year. The writer believes that he is making no rash statement when he gives as his opinion that no battle, no treaty, no ecclesiastical council has had a more profound effect on human affairs than has the development of this simple flexure formula.

The Development of the Flexure Formula. The father of the science of the strength of materials is none other than Galileo (1564–1642). He it was who abandoned the Platonic attitude of intellectual aloofness, and who did not disdain to study the art of the craftsman and to use "mean and manual labor" in experimentation. He was lead to an interest in the development of a formula for beams by observing the practices and the accidents in the Venetian shipyards, and he soon saw that the practice of designing large beams geometrically similar to successful small beams was at times a dangerous practice. He then brought out the idea of external bending moment and internal resisting moment (although he did not use these terms) very much after the manner of the modern engineering textbook. He did not grasp any idea of *elastic*

* For a more detailed discussion of this point see *Science* for July 13, 1928, pp. 24–29 inclusive.

GALILEO, 1564–1642

The great pioneer apostle of experimentation as a means of apprehending truth. Made the first analysis of the flexure problem, developing the idea of bending moment and of resisting moment, but not noticing the phenomenon of elastic deformation under load.

JAMES BERNOULLI, 1654–1705

One of the earliest investigators (though probably not the first) to notice not only tensile strain but compressive strain also in a beam. Developed the idea of the elastic curve and stated that the bending moment at any point was inversely proportional to radius of curvature at that point. Doubted the correctness of Hooke's law, probably because he experimented on materials stressed beyond their elastic range.

EULER, 1707–1783

Developed rather fully the idea of elastic curve as we know it today (although our modern notation is different from Euler's). Developed the idea of failure by elastic buckling, and the Euler formula for failure of long columns.

NAVIER, 1785–1836

Professor at the French School of Bridges and Roads. The first to give a complete statement of the flexure formula as we know and use it today. The father of modern Engineering Mechanics of Materials and of the modern Mathematical Theory of Elasticity.

deformation. To him a solid was a solid, inextensible and incompressible until it broke. That assumption means uniform distribution of pull all over any cross-section of a beam, with a resultant pull at its centroid. For rectangular beams (and in Galileo's day 95 percent of structural beams were rectangular) this method enables the designer to *proportion* rectangular beams as correctly as does our modern flexure formula, but his method fails when applied to beams of cross-section other than rectangular. However we do well to remember Galileo's success in stating the principle of bending moment and resisting moment rather than emphasizing his failure to develop the laws of elastic deformation.

Some thirty years after Galileo's experiments Robert Hooke made public the statement of his famous law "as the force so the stretch," or, in modern terms, stress is proportional to strain. Robert Hooke * is a very striking and very human figure of the period of Wren, Boyle, and Newton. He has been characterized as the first mechanician of his day and in all his work showed a marvelous skill in devising and handling apparatus, combined with a distinct weakness when it came to putting the results of experimental work into generalized mathematical formulas. His statement of his law was founded upon a frankly experimental basis. In his lecture "De Potentia Restitutiva" (the title is in Latin, but the text is in English) his justification of his law is contained in the following quotation:

> "Now as the Theory is very short, so the way of trying it is very easie.
>
> "Take then a quantity of even-drawn Wire, either Steel, Iron, or Brass, and coyl it on an even Cylinder into a Helix of what number of turns you please, then turn the ends of the Wire into Loops, by one of which suspend this coyl upon a nail, and by the other sustain the weight that you would have to extend it, and hanging on several weights observe exactly to what length each of the weights do extend it beyond the length that its own weight doth extend it to, and you shall find that if one ounce, or one pound, or one certain weight doth lengthen it one line, or one inch, or one certain length, then two ounces, or two pounds, or two weights will extend it two lines, two inches, or two lengths; and three ounces, pounds or weights, three lines, inches, or lengths; and so forwards."

Hooke's law is thus seen to be a law founded directly on observation, and, judged by modern standards, on crude observation. Hooke himself seemed to recognize no limits for the application of his law, and, in fact, was not particularly interested in the *strength* of materials, but rather in their *stiffness*. He developed his law in connection with the use of watch springs, and to him the laws of elastic deflection were of more interest than considerations of elastic strength.

* After several years of search the writer has been unable to find any portrait of Hooke.

Today we would by no means accept a proposed law on such a basis of evidence as Hooke offered in 1678, yet we must recognize the fact that subsequent study and experiment has shaken but slightly our faith in the practical reliability of Hooke's law—within limits.

Hooke noted the stretches and compressions which exist in a bent beam, but took no steps towards the development of a correct flexure formula. With Hooke's law and Galileo's idea of bending moments and resisting moments, the raw material for such a formula was at hand, but the actual development required a period of a century and a half.

In this period of development the first figure to appear after Hooke is Mariotte* (1620–1684). Probably without knowledge of Hooke's work, Mariotte announced the same law of proportionality of stress to strain. He observed the fact that there was stretch in the fibers on one side of a bent beam, and compression in the fibers on the other side. Without any clear evidence, experimental or logical, he stated that at mid-depth of a beam there is a layer which is neither stretched nor compressed, and thus was the first to give the idea of a neutral axis. Much discussion followed between the advocates of Mariotte's picture and those of Galileo's—a discussion which lasted well into the nineteenth century.

James Bernoulli (1654–1705) in 1694 indicated the differential equation of the elastic curve of a bent beam, basing his determination on the theorem that at any point the radius of curvature of the bent beam is inversely proportional to the bending moment at that point. To use this differential relation it became necessary to evaluate various constants, among them the one we now know as the modulus of elasticity. Bernoulli was not able to do this, and it remained for the combined work of Coulomb, Young, and Navier to accomplish this evaluation.

Bernoulli doubted the truth of Hooke's law, probably because his experiments were carried out under stresses well beyond the limit of proportionality of stress to strain. He seems to be the first to investigate the elastic curve of a beam. Varignon (1654–1722) also doubted the proportionality of stress to strain, and wrote a memoir defending Galileo's treatment of the flexure problem, at least to the extent of neglecting the compression in a beam.

An interesting figure in the development of the flexure formula is Parent, who published a memoir in which he reasoned from the truth (now evident enough) that over any cross-section of a beam the total tensile *force* must balance the total compressive *force*. Parent seems to have come to the very threshold of giving a complete

*The writer has been able to find no portrait of Mariotte, of Parent, or of Coulomb.

statement of the modern flexure formula, but his work seems to have been buried for many years, and recognition has come long after his day. We are lead to wonder how many unknown investigators, whose work has never become known, worked out the flexure formula.

The correct location of the neutral axis (better the neutral surface) in a beam became known through the work of Coulomb, whose memoir on resistance of materials was published in 1773. However, his discussion was so condensed that it was not generally understood for some forty years. It is of interest to note that Saint Venant in his historical summary of the early history of the mechanics of materials * states that after the publication of Coulomb's memoir the consideration given to elastic curves, the elastician's problem, grew less, while the emphasis shifted to the problem of resistance to flexure, the engineer's problem. Coulomb's memoir was written as the result of the author's experience in Martinique as a military engineer. Coulomb introduces the consideration of shearing action in beams.

Navier (1785–1836), a professor at the famous French technical school of roads and bridges, is to be given the credit for the final development of the modern flexure formula. In his earliest treatments he made the error, often repeated by subsequent writers, of assuming that for any cross-section of a beam the sum of the *moments* of the tensile forces equals that for the compressive forces—a statement true only for symmetrical sections. Navier integrated the work of Galileo, Hooke, and Coulomb, and used the idea of modulus of elasticity developed in 1807 by Thomas Young. The equivalent of the simple flexure formula is given us by Navier under the name of "equation of permanent cohesion," but he did not use the modern term "moment of inertia," using an integral expression instead. A modern reader of Navier's notes finds the flexure formula almost concealed within a discussion of the nature of cohesion and an elaborate mathematical study of certain elastic conditions.

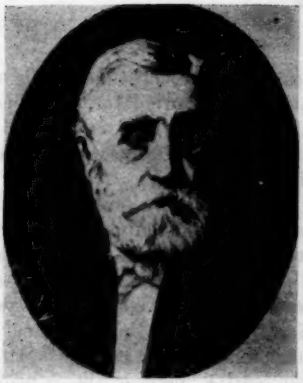
As in the case of Hooke, so to a less degree with Navier the simple, concise, and vitally important contribution which each made to the science of mechanics of materials was not given the great emphasis which it has been found to deserve. This, of course, is a common happening in the development of any scientific theory.

It may be noted that nearly all the mathematical development of the flexure formula was done by workers on the continent of Europe, and it is an interesting fact that some ten or twelve years

* This summary given by Saint Venant, together with a historical sketch by the French engineer Girard, is our chief source of knowledge of the history of the early days of the science of mechanics of materials.

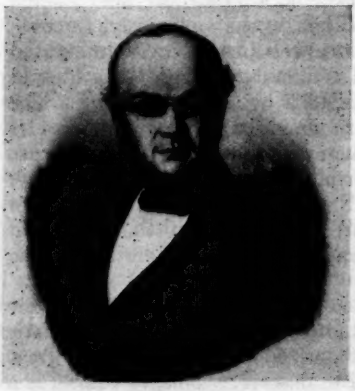
TREDGOLD, 1788–1829

A representative "practical" British builder who, while not using a correct form of the flexure did noteworthy service in leading builders to consider the use of analytical methods in practical design. Shares with Barlow the distinction of being a pioneer writer of "handbooks" for structural engineers.



SAINT VENANT, 1797–1886

The pupil of Navier. Developed Navier's work into the modern Mathematical Theory of Elasticity. A man with a mathematical turn of mind, who yet did not lose sight of the necessity of serving the "practical" structural engineer and machine designer.



WEISBACH, 1806–1871

The outstanding pioneer in harmonizing mathematical analysis and practical structural problems in Germany. His text on Mechanics of Engineering could be used with good success as a textbook in a present day engineering school.

RANKINE, 1820–1872

The outstanding British pioneer in harmonizing theory and practice in engineering work. His textbook on Applied Mechanics has served largely as a general model for texts in English ever since its appearance. He may be characterized as an engineer with a taste for and an ability to use mathematical analysis in his everyday work.

elapsed between the publication of Navier's notes and the general use in England of the correct flexure formula. The English engineers were very "practical" men. Two of them Tredgold and Barlow published working formulas for beams before the appearance of Navier's notes, and these working formulas followed the old erroneous assumptions of Galileo. It was some ten or twelve years later that Barlow corrected his book to agree with Navier. It is also worthy of note that before Barlow made this correction he made a number of rather delicate measurements of strain in beams, finding by direct measurement that the neutral surface was indeed at the centroid of a section. The practical British mind of 1830 preferred to have mathematical reasoning reinforced by experimental study before placing full confidence in it.

An interesting branch line of the development of the flexure formula is found in the work of Euler. Taking Bernoulli's work on the elastic curve he developed its treatment to what is essentially its present form and then applied this line of reasoning to the behavior of long columns under compression, giving us the Euler column formula. This happened years *before* the work of Navier. Engineers have often been puzzled to account for the neglect of fiber stress and strength of material in the Euler column formula. The reason may well be that he developed it as an elastician interested in deformation rather than stress and developed a formula for failure under a very special condition, that of disastrous buckling before elastic failure of fracture occurs; he had no interest in elastic failure or in fracture, only in excessive buckling under elastic conditions. His column formula belongs in a different category from the flexure formula.

Since the days of Navier the development of the science of mechanics of materials has followed two fairly distinct lines; (1) the development of an elaborate mathematical theory of elasticity and (2) the development of a comparatively simple mechanics of the strength of materials used by engineers for everyday computation work. The great figure in the development of the mathematical theory of elasticity is Saint Venant, the pupil of Navier. Many other distinguished elasticians have worked since 1830, but Saint Venant's methods are the outstanding guide for students of that theory.

In the field of engineering mechanics of materials two names stand out, Weisbach and Rankine. Weisbach at the Freiburg School of Mines and Rankine at the University of Glasgow put the essentials of the simplified theory of elasticity used by present day engineers into substantially their modern shape. Today classes in mechanics of materials could be taught with good effectiveness using Weisbach or Rankine as a textbook—in fact up to a very few

years ago Rankine's "Applied Mechanics" was so used in at least one American technical school.

As these two divisions of the science of mechanics of materials develop their fields overlap, especially in machine design, and it seems probable that not many years hence engineering students will be required to become familiar with some of the problems in the theory of elasticity which now are regarded as beyond their reach. It is to be noted also that the students of the theory of elasticity have been mainly interested in the *deformations* of materials, and until recently have not given very careful thought to problems of strength; this means they have been interested in problems of integrated elastic action. On the other hand the engineers have been relatively little interested in deflections and have been greatly interested in *maximum* stresses and strains, a problem of *localized* action. Here again the broadening of both fields tends to bring these two branches of study together.

The Modern View of the Theory of Elasticity. The theory of elasticity uses such elegant mathematical methods that it seems almost a desecration to question its accuracy. Yet when it is to be applied to the behavior of actual materials it is certainly necessary to ask what are its basic assumptions as to the nature of solid materials and how closely the structure and action of the materials used in structures and machines corresponds to these assumptions.

The fundamental assumptions of this theory include the following:

1. Materials are homogeneous,
2. Materials are indefinitely divisible without change of physical properties,
3. Hooke's law holds.

Even a casual examination of the actual materials used in machines and structures shows that the first two assumptions are not rigidly true for actual materials and a careful study of stress-strain diagrams seems to indicate that Hooke's law must be regarded as a very satisfactory approximation rather than a precisely stated law.

About the middle of the nineteenth century the British mathematician Stokes justified the theory of elasticity as applied to metallic materials by showing that the general deformation of laboratory specimens under load coincided very closely with the deformations calculated by the theory of elasticity. As noted previously, it is this general deformation which is of prime interest to the elastician and such general deformations in agreement with the theory of elasticity would not be at all inconsistent with the existence of many local deformations widely differing from those calculated by the theory. The engineer, interested in the maximum

intensity of strains and stresses at any location, could hardly accept this proof as satisfactory.

Today we realize that the revelations of the microscope and of X-ray crystallography indicate that in any structure or machine part there may exist many localized stresses widely different from those calculated on the basic assumptions of the theory of elasticity and still more widely different from the stresses computed by the simplified formulas which engineers commonly use. Our whole elastic theory, and, of course, the flexure formula which is a part of the statement of that theory, is a generalized, "statistical" statement—a cartoon rather than a picture correct in every detail.

The Value of the Flexure Formula. The recognition of the limitations of the theory of elasticity, and of the flexure formula, in no wise diminishes its value to the designing engineer. For structural parts made of even moderately ductile material the existance of high localized stresses does no appreciable damage, so long as the load is not repeated tens of thousands of times. For material subjected to oft repeated loading it must be recognized that the common flexure formula must be supplemented by some means of computing, or at least estimating, localized stresses—stresses at the root of a screw thread for example. The more elaborate theory of elasticity gives the means of computing some such stresses and various experimental methods, such as the study of transparent specimens under polarized light, the study of specimens made of brittle materials and the study of the development of visible strain lines on metallic specimens, may be used to obtain a very fair estimate of the magnitude of localized stresses.

We may as well recognize that such means, including the use of the mathematical theory of elasticity, are by no means exact, but we have the comforting fact that, in all cases so far observed, even under oft-repeated loading, the strength of the parts has always been found to be greater than that indicated by a study of localized stress by the theory of elasticity, either by the use of mathematical methods of stress-analysis or by any of the experimental methods noted previously. We play safe when we make a careful study of stress-distribution by the use of the theory of elasticity.

The writer is of the opinion that structural engineers and machine designers have sometimes been guilty of formula idolatry. The flexure formula, like every mathematical formula for the strength of materials no matter how elegant, is not to be worshipped, but to be evaluated and its limitations examined. All formulas are to be used wisely and carefully and no friend of the flexure formula need worry about its future importance to the engineer.

ORGANIZATION AND ADMINISTRATION OF THE DRAWING DEPARTMENT *

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In view of the looseness with which the two chief words in the title of this paper are often used, it seems desirable at the outset to make some differentiations which will help in clarifying the suggestions and recommendations to be presented later.

For present purposes we shall use the term organization in two senses, to be distinguished by two modifiers: namely, external and internal. The term external organization will be used to designate that instrumentality which has been created by college or university authority to provide the means whereby certain specific and well-defined results, known as training in engineering drawing and descriptive geometry, can be obtained. This organism, or organization, or "machine," if you will, is to be known here as the Drawing Department, although in this country and Canada, at least a dozen different names are used to identify it which, in some instances, do not give to the organization the prestige and dignity of a drawing department. Size, tradition, and corporate arrangement in a particular institution naturally and materially affect the type and name of the external organization.

The organic or primary purpose of the builders of this external organization should be to create an instrument and conditions that will make it possible to do the assigned work effectively, economically, and in complete harmony with all other units of activity in the engineering college and with other served divisions of the school. A fact never to be lost sight of is that the drawing department is only one organism among several in a smoothly functioning whole, and that it is a servant to all the other organisms in the body politic, however independently it may function in accomplishing its own ideals and purposes.

For the sake of comparison only we have termed this organization known as the drawing department a machine. In spite of its being effective and economical in operation at the time of its construction, a machine is always subject to redesign and reconstruction

* Presented at the Engineering Drawing and Descriptive Geometry Session of the Summer School for Engineering Teachers, June 19, 1930.

as operating conditions change. So too in the case of the machine with which we are dealing. Increases in enrolments, wider range of service both within and without the college, new educational principles, and numerous other factors, have made it imperative that redesign of the external organization be undertaken in numerous instances in the last twenty-five years.

It appears, however, that in no division of engineering education has tradition and name been such a deterrent to the evolution and emergence into a departmental organization of a well classified and definite body of subject material as has been the case in engineering drawing and descriptive geometry. Of the more than one hundred and fifty institutions in the United States and Canada giving collegiate engineering instruction, hardly a third have created a free and separate departmental organization for the teaching of these two subjects which so naturally group themselves together. In ninety-three of the best institutions in this country the ratio is two to three. It is the writer's opinion that another third of these institutions would profit greatly if they too should set up organizations that would function as a complete machine instead of a wheel within a wheel as is now the case. We recognize the futility of such a suggestion in the case of some schools, but where it is at all economical it should be done with alacrity if the institution wishes to capitalize to the fullest the benefits that may be derived from unhampered initiative and well designed internal organization. Numerous reasons may be cited in support of this view. Three are apropos at this stage.

It is an obvious fact, in the first place, that the more limited specialized professional point of view of a major engineering department cannot but have a materially narrowing effect on the drawing division under its jurisdiction. Engineering drawing is not simply mechanical drawing, nor is it drawing in a mechanical engineering department. It is not machine drawing, or architectural drawing, or structural drawing, it is more than any one or all of these. Engineering drawing is the language of engineers. It must be taught as such without the flavor or bias of a restricted point of view. The language is too rich in idiomatic expressions from various mother tongues to overlook the advantages of having representatives of the various tongues on the department staff.

In the second place, it is quite clear, we think, that the broadening and sympathetic influence which we wish the drawing department to exercise on our freshmen can best be imparted by an organization in itself broad because it is composed of men chosen from the several professional divisions of engineering. Interest in this particular phase of teaching is not hard to secure in a department which is free to decide its teaching objectives and the methods

of attaining these objectives. It is well known that quite different schemes must be employed in handling freshmen from that used with upperclassmen.

In the third place, the type of work done in a department cloistered within another major department is likely to become more technical and less educational as pressure of numbers increases. We believe that engineering drawing and descriptive geometry must be put on a plane of high educational value along with courses in mathematics, chemistry, physics and the like, before a department giving the instruction will ever be considered anything but a vocational unit. Formerly this may have been the correct goal to achieve. It is no longer such in the present day list of educational objectives in an engineering college.

Other less cogent reasons for consummating the action recommended wherever feasible will appear later in our discussion.

Reference must necessarily be made at this point to the inner parts and workings of this organism called the drawing department. These inner parts can be best distinguished from the whole by placing them under the heading or classification of the internal organization of the department. It is in connection with the building and functioning of this internal organization that administration enters and becomes the important coordinating and driving force. The writer holds that in spite of all the disadvantages that accrue from incorrect name, from faulty structural make-up, and from traditional placement of the drawing department the machine can be made to function satisfactorily if its internal parts are well designed and properly coordinated through forceful and intelligent administration. Administration functions best, however, when there is the least of it, as was the case on the proverbial educational log with a student on one end and a Mark Hopkins on the other.

The design of the internal organization, as we have called it, should be strictly the job of the professor in charge of the department; always, of course, with the help and advice of the members of his staff. Effective administration is possible only when those clothed with its authority proceed to establish a working pattern which all may help to fill in. Effective organization must proceed on the assumption that there is to be effective administration, that is, definitely centered responsibility. It behooves us, therefore, to set up some definition of administration that will form a basis for separating these two primary elements in our discussion, in so far as it is possible to separate them, in order to bring out the true functions of internal organization and administrative control and direction.

Administration, as we conceive it, is the animate force or dynamic that puts spirit, purpose, idealism, and direction into the

organization which has been created. It gathers its authority, of course, from the creator of the machine, namely, the college of engineering. It obtains its dynamic and idealism largely from the individual members of the department, however much these members may be unaware that such is the case. This flow of administrative force around and through an organization is quite like the flow of the life blood of the human system in that it penetrates to the extremest detail and returns to its source markedly affected by each cell through which it has coursed.

From the foregoing it is clear, we think, that internal organization and administration cannot be separated from each other practically or rhetorically by any sharp and clear cut line of division. Organization is comparatively permanent, however, while administration may and often does change as the workers come and go. Organization is and should be slow to respond and to adjust itself to the demands of opportunists from within and without; administration on the other hand, is likely to be too quick to react to any will of the wisp.

It will now be in order to state what is conceived to be the primary purposes of a drawing department in terms of specific goals and objectives, toward the attainment of which both internal organization and administration must strive, leaving the reader to determine for himself and for his department in just which element success or failure accrues under the conditions existing in his own institution. It is not hoped or presumed that these observations will fit every current situation. Standardization of departments is not to be sought. No worse evil could befall us than that we should become like casts from a single mold. It should be understood, however, that the ideal department we now have in mind is one the external organization of which is freed from the mothership of any major department of the college and which has been christened what it really is, namely, an engineering drawing department, rather than a department of mechanical drawing, applied mechanics, graphics, or any other cognomen equally incorrect and less fruitful of deserved prestige and clarity. It is of such a department and its possibilities that the remaining sentences of this paper are written.

The purposes or goals of internal organization and administration in this ideal department may be enumerated as follows:

1. The purpose to bring the department into educational and professional harmony with the purposes of the larger unit which it serves, namely, the college or school of engineering and architecture and, in some cases, other served departments of learning.

It is in respect to this objective that failure may easily occur. Independence in action may lead to autocracy in plan and con-

ception. Restricted action may lead to abandonment of plan and idealism. As stated previously, the drawing department must be organized and administered with its compass needle always pointing to the pole of coordinated engineering education. The optimum of success is attained when engineering drawing contributes its maximum to the life of the college in which it exists and to the lives of the students with which it contacts.

2. The purpose to make as effective and efficient as possible all forms of instruction given in the department including recitation, laboratory, and quiz work, by means of:

a. The utilization of proved educational methods such as sectioning of students on some sound basis of selection, elimination of tedious and wasteful employment of instructors' time in recording grades, preparing class exercises, filing plates and other purely clerical work.

b. By close personal contact of the professor in charge with the younger teachers of the department in their daily work.

c. Through proper choice and stimulation of staff personnel.

d. By means of the subdivision of direction and responsibility into the hands of committees under the leadership of active and interested members of the department, and

e, *f*, *g*$\cdots$*n*, and on. Through numerous tried and untried educational stimulants and devices which fire the imagination of the students and keep the staff on tip-toe.

3. Since the department of drawing deals largely with freshmen students, it should be definitely the aim of the administration and organization to inculcate those personal characteristics and attitudes in the students which are distinctly of the professional rather than of the vocational type. It is doubtful if we should even assume that the product of our class and drafting rooms will be found in any considerable numbers on industry's drafting boards in the future. Observations of the writer indicate that less and less are we training graduates to be draftsmen. Industry seems to be finding its supply in the high schools and vocational schools. In some quarters it is becoming a well established opinion that engineering drawing is not of collegiate grade. One well-known institution does not even teach freshman drawing. We repeat, therefore, that administrators of drawing, through their individual staff members, must replace the vocational point of view and method with professional and educational substitutes. Too much emphasis cannot be placed on this phase of the drawing department's activity in the future. This in turn again requires the employment of high grade professional personnel.

4. Fourth in our statement of purposes should be that of giving academic prominence and prestige to the department of drawing in

fully deserved portion so that drawing teachers may receive salaries and rank comparable with other teachers of the college, and so that they may hold positions of influence on committees and in councils on educational matters. This we believe is coming to pass to a very marked degree in these later years all over the country, but it cannot be attained by any sounding of timbals or blowing of horns; it must emanate from sound and substantial progress within the organism itself, which progress can be unmistakably seen in the results.

5. A fifth goal of organization and administration in a drawing department should be to provide academic opportunity and encouragement to the teachers so that they may advance in educational and professional standing among their colleagues through graduate work leading to advanced degrees in the field of their professional specialization and through teaching schedules that include a course or courses in the department of their specialization wherever this is at all possible. It would appear that this latter procedure has more merit than the present practice in many departments where all the teachers are from one field of engineering practice and confined in their allegiance to the corresponding department.

6. Security and freedom of experimentation and exploitation of ideas and hunches which staff members may have should be made certain through well established and adequate annual budget provisions for the department. Nothing will stifle initiative more certainly in any ambitious teacher than to be told that there is no money to test out the worth of a promising "hunch" or idea. Three to four dollars per student is suggested as a working basis. Much of this can be accumulated through the collection of fees.

7. An atmosphere should be created in the drawing department that will encourage every member of the staff to attach himself to a national organization or association with others that will permit him to present his opinions and suggestions in such a way that they will receive the widest attention and have the greatest influence on those whom it is desirable he should know and be known by. The organization under whose auspices we are now assembled has done much in the past and will do more in the future to raise the status of the engineering teacher and to make his voice effective in the councils of educational leaders. The drawing teacher must not lag in doing his part.

8. Concomitant with the need for a more educational and professional point of view in the drawing department in both organization and administration, comes the call for leadership and direction from the rapidly multiplying junior colleges and the liberal arts and science colleges who are establishing pre-engineering courses. Because of the extremely high local pressure exerted on

these institutions to supply purely local vocational demands, there is little possibility of their progressing beyond the status of vocational training without there being very definite patterns of educational and professional design in the engineering colleges to which they may turn for guidance. The drawing department must know its objectives and the objectives must be so certainly attained by the processes and procedures of the department that an outsider may clearly see their accomplishment and be guided in a very positive way in his application of the demonstrated principles.

Apropos of this bitterly opposed junior college movement in some quarters and equally enthusiastic support in others, it is not out of place to remind administrators in drawing departments that they must more clearly than any others discern the dual purpose underlying the establishments of these institutions. The unhappy lot which has befallen some of them through misguidance and misunderstanding of their dual functions can be laid directly at the door of ignorant leadership. Drawing may be made to function in the so-called terminal scheme of operation alongside the collegiate courses, but certainly it should be taught on a higher plane of academic conception than the trade school ideal if we are to use it in both fields. Of course, this observation applies to other work such as mathematics, English and the like.

Summarizing these somewhat loosely connected observations, we emphasize again that much is to be gained in the standing and effectiveness of more than four hundred teachers of engineering drawing in more than one hundred and fifty schools and colleges of engineering through greater unity and solidarity of outward form and purpose in both organization and administration; that it is desirable to adopt the name engineering drawing wherever possible to capitalize fully the widest professional aspects of our work; that we shall administer and be administered best when we recognize administration as the dynamic leadership in a department to which all may contribute rather that a clerkship or dictatorship to be avoided as much as possible; that there must be specific objectives set up on both the educational and professional sides quite apart from the mere routine of class and drafting room processes, which objectives encompass the academic, professional and material progress of the department as a whole and its personnel as individuals; and finally that prestige, prominence, and leadership in organization and administration are secured in drawing departments in the same way as elsewhere, namely, by the departments knowing their objectives and attaining them through sound procedures that are perfectly clear to even the casual observer.

REPORT OF COMMITTEE NO. 12—ENGLISH, JUNE, 1930

During 1929–1930, your Committee on English has continued the study of first-year English courses for technical students. The material from the schools holding institutional membership in the Society is being organized and classified. Already one division, that of independent (and sectarian) universities, has been completed. Others will follow in due course of time.

The effort of the Committee to arouse group consciousness among English teachers particularly interested in English for engineers has been increasingly successful. A fairly complete list of all those directing the courses in English offered technical students in the United States and Canada which has been compiled is making it possible for the Committee to extend its contacts through personal correspondence, and to exchange ideas on problems of common interest. Projects for the ensuing year include further study of first-year composition, and a survey of the courses in public or oral exposition, and in literature, which are rapidly becoming a part of the training in English in engineering colleges.

The Conference on English at the Annual Meeting, "The First International Conference on the Teaching of English to Technical Students, "made evident that everywhere English teachers have to take into consideration the diverse character of the background of first-year students, and the great variation in the secondary school training in English. One of the most difficult problems is the necessity of converting a group of students ranging from the very poorly prepared to the really efficient into a homogeneous group.

Through the developments in the teaching of English in the technical schools of the United States has come the increased recognition of the value of intelligent, sympathetic training in English composition and of inspiring, dynamic study of English literature which has resulted in a very just increase in the amount of English required and its closer correlation and integration with the whole educative process. Experiments have been made with varying success with combination courses in English and history, or economics, or government, and in a balanced course including English composition, English literature, and public speaking. Special courses in technical writing, in technical journalism, in report-writing, and in the preparation of theses have emphasized the tool value of English composition, while a great variety of courses in literature have been formulated to meet the special interests of technical students. The latest, and at present striking

development in the teaching of English in the United States has been the sudden increase in interest in public speaking and oral composition which threatens to become almost a popular movement.

There is a resurgence of interest on the part of engineering college administrators in the English courses offered their students. Next year for the first time in several schools the English courses for engineers will emerge from "the usual college English courses" and will be taught by an English instructor specially chosen because he has shown sympathetic interest and has been successful in teaching engineers. In some cases, such a man will be put in charge of all the work in English for the College of Engineering. The Committee feels encouraged as to the prospects for the future of English courses for engineers. In the past, the recruiting of young instructors has been one of the difficult problems; but it is hoped that as the courses in English for engineers gain recognition, it may be increasingly evident that there are opportunities in the teaching of English to technical students that will bring rewards in the way of personal satisfaction, professional recognition and advancement that every sincere teacher has a right to expect.

SADA A. HARBARGER,
Chairman

NEW MEMBERS

DRUMMOND, GARRETT B., Assistant Professor of Mathematics, Oklahoma A. & M. College, Stillwater, Okla. E. L. Patterson, G. G. Gladney.

HOLLAND, UBERT C., Instructor in Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. H. C. Berry, John A. Prior.

JONES, WALTER B., Research Professor of Education, University of Pittsburgh, Pittsburgh, Pa. F. L. Bishop, Nell McKenry.

MATHEWS, RALPH T., Instructor in Mechanical Engineering, Duke University, Durham, N. Car. Walter E. Farnham, Arthur W. Leighton.

ENTROPY CHART

Professor O. K. Harlan of the Pennsylvania State College has completed a temperature-entropy chart for ammonia. The chart is of such large size (about 22″ × 32″) with the values of temperature and entropy plotted to such ample proportions that they may be read directly with great accuracy. This chart permits the reading of all values at once which renders unnecessary the laborious interpolation of values from tables.

One of the noteworthy features of the chart is the fact that zero of entropy is at minus 40 degrees Fahrenheit, a temperature well below the temperatures which are common in practical refrigeration. This is of considerable importance because negative values of entropy are thus avoided and the probability of errors reduced in calculations based upon the chart.

Some authorities have prepared numerical tables for ammonia with zero of entropy at 32 degrees Fahrenheit but as 32 degrees is just the freezing temperature of water and most refrigeration operations are conducted at temperatures below 32 degrees, negative values for entropy for temperatures below 32 degrees are likely to cause confusion and errors in calculations.

The data used by Professor Harlan in making his chart are based upon investigations of the Bureau of Standards at Washington, D. C. These data are recognized as the latest and best available.

Another interesting feature of this chart is a representation of the "dome" in the yet unexplored and uncharted region of the still higher temperatures which, however, are of no practical value at present in refrigeration. It shows very clearly the effects of "wet" and "dry" compression.

This chart is of especial value in connection with the study of the thermodynamics of refrigeration and is the only one of its kind in existence. It is copyrighted by the author.

Each of the multitudinous lines on the chart is drawn through points plotted at close intervals, each point being plotted as the result of a series of many calculations. The whole work is the (product) of months of painstaking effort.

The chart is useful in factory design work of refrigerating machinery as well as in technical class instruction and its field of usefulness is enlarging.

A nominal charge is made that does not cover the cost of production.

SECTIONS AND BRANCHES

The **Middle Atlantic Section** of the Society for the Promotion of Engineering Education held its annual spring meeting at Lehigh University, Bethlehem, Pennsylvania, on Friday, May 2d, and Saturday, May 3d, 1930. Registration was held in the new Packard Laboratory at 1 o'clock Friday, May 2d, and was followed by a most interesting trip to the plant of the Bethlehem Steel Company.

At a dinner held Friday evening in the Bethlehem Hotel, President Charles R. Richards of Lehigh University, Chairman of the Middle Atlantic Section, presided. After some remarks by President Richards, Professor F. V. Larkin of Lehigh, Professor Harry P. Hammond, and Professor Hehre of Columbia, President Richards called the business meeting to order.

Secretary Rockwell read the minutes of the Bell Laboratories' meeting held December 14th, 1929. Charles G. Thatcher of Swarthmore College was elected secretary, to succeed Professor Rockwell and to serve until the December meeting.

A motion was carried that the members of the Middle Atlantic Section be asked to contribute small amounts ($1.00 suggested as the suitable amount) at the present time for the expenses of the section, and that there be no further solicitation until further funds are needed.

Invitations from Director S. S. Edmands of the Pratt Institute and President K. G. Matheson of Drexel Institute, for the December meeting were presented. Motion was carried that we accept the invitation of Drexel for the December, 1930 meeting of the section.

Motion was passed that a committee on resolutions be appointed by Professor Hammond.

The meeting then adjourned.

On Saturday morning, May 3d, at 9 o'clock the members of the section were entertained by a trip of inspection of a number of the buildings and laboratories of Lehigh University.

At 12:30 an invitation luncheon was served in the Packard Laboratory and at 2 o'clock President Richards called to order a meeting in the auditorium of the Packard Building.

The following representatives of industries presented their viewpoints on the recruiting of engineers:

Emerson B. Roberts, Westinghouse Electric & Manufacturing Co.
O. W. Eshbach, American Telephone & Telegraph Co.
E. G. Bailey, Bailey Meter Co. and Fuller Lehigh Co.

M. M. Boring, General Electric Co.
Herbert A. Wottrich, Public Service Electric & Gas Co. (New Jersey).
Grover C. Brown, Bethlehem Steel Co.

There was considerable discussion of these presentations by both the representatives of industry and of the colleges.

The report of the committee on resolutions presented by Mr. Emerson B. Roberts as follows, was unanimously adopted:

Resolved: That the members of the Middle Atlantic Section of the S. P. E. E. wish to express their thanks and appreciation to President Richards and Lehigh University for an interesting and entertaining program, a most delightful luncheon and a well arranged and instructive opportunity to inspect the work and equipment of the University and of the Bethlehem Steel Company.

Committee on Resolutions:

R. L. SPENCER, *Chairman*,
T. H. HARRINGTON,
E. B. ROBERTS

At 5:30 P.M. the meeting adjourned.

CHARLES G. THATCHER,
Secretary

COLLEGE NOTES

University of Kansas.—Professor F. E. Johnson, head of the Department of Electrical Engineering, resigned to take a similar position at Iowa State College. The position at the University of Kansas is filled by Professor D. C. Jackson, Jr., of the University of Louisville.

Professor H. W. Anderson of the Department of Electrical Engineering will be on leave of absence during the school year for study at the Massachusetts Institute of Technology.

E. F. Kindsvater of the Department of Civil Engineering has resigned to become an inspecting engineer for the Phillips Petroleum Company. The position will be filled by Mr. D. D. Haines of Washburn College, Topeka, Kansas.

Return to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Society for the Promotion of Engineering Education

Date.....

THE UNDERSIGNED desiring to become a member of

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

hereby agrees to conform to the requirements of membership, if elected and submits the following:

STATEMENT OF QUALIFICATIONS

Full Christian Name and Surname.....
Print Last Name First Middle

Mailing Address (Number and Street).....

Post Office (City and State).....

Full Title of Professional Position.....
(Title) (Department)

Full Name of Institution.....

(To be Signed by Two Sponsors)

SPONSORS {.....
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ADDRESSES UNKNOWN

If you know the present addresses of the following members, please send them to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

David M. Bavly,
Frank S. Beale,
William D. Bliss,
Edward P. Boyd,
F. A. DeLay,
E. L. Ericksen,
Ray Flagg,
W. B. Getchell,
J. B. Hamilton,
Forrest M. Hatch,
Frank B. Lindsay,
Fred Merryfield,
G. I. Mitchell,
V. C. Muncy,
John E. Nicholas,
William A. Oliver,
Jas. R. Schermerhorn,
Edward S. Sheiry,
Earl A. Stewart,
D. L. Turner,
Arthur E. Wells.